A MANUAL OF OPERATIVE SURGERY

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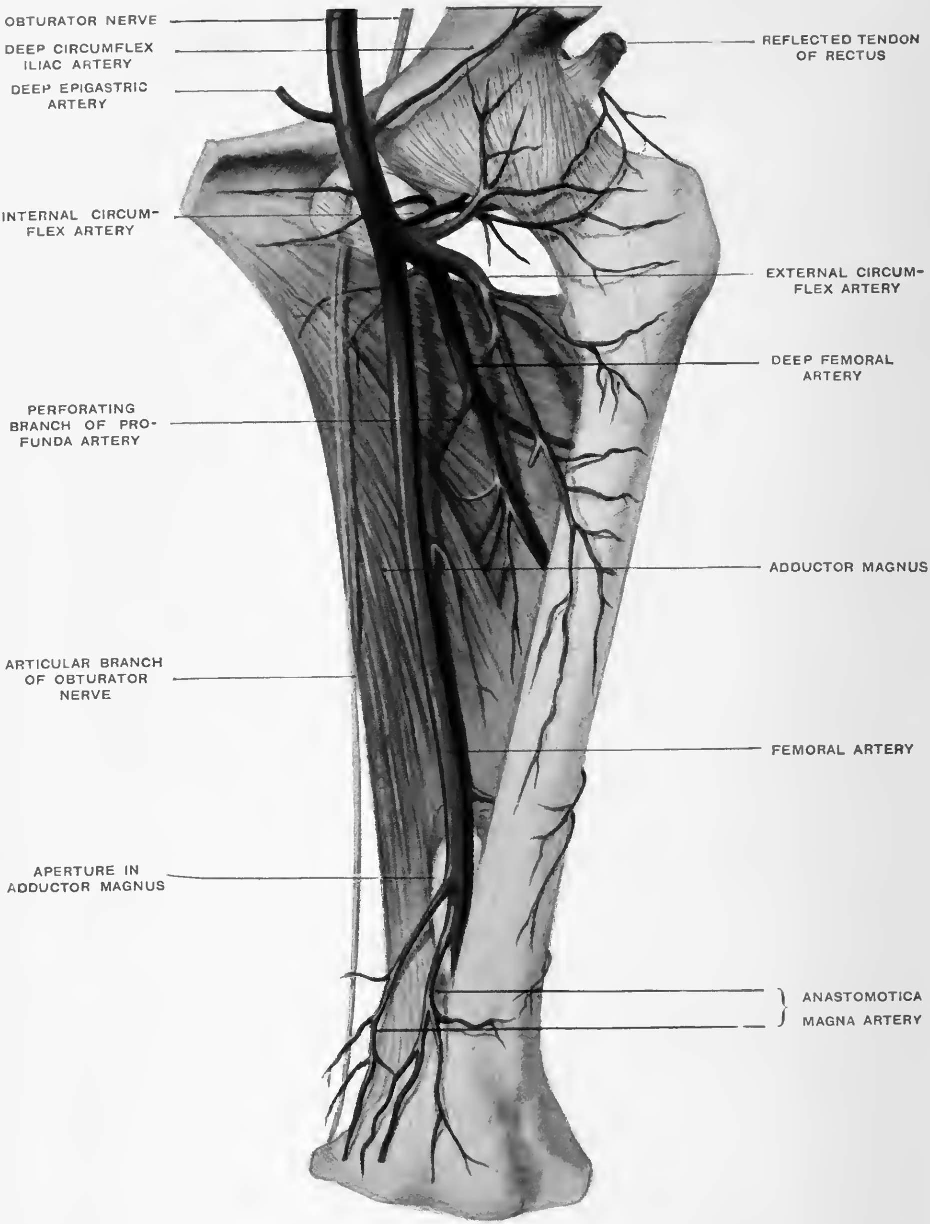

THE FEMORAL ARTERIES, WITH THEIR MAIN BRANCHES (*page 410*).
(From a Dissection in the London Hospital Museum.)

A MANUAL OF

OPERATIVE SURGERY

BY

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PREFATORY NOTE TO VOL. II

THE amount of time and labour devoted to the revision of the whole work, the numerous additions and alterations made to it, and the pressure of other professional work, will, it is hoped, to some extent excuse the delay in the publication of this volume.

The first two chapters, Operations on the Skull and Brain, and on the Middle Ear, the Mastoid Antrum, etc., have been revised and largely re-written by Mr. A. J. Walton, and the short chapter on Tendon-Suture and Tendon-Grafting is entirely his work.

J. H.

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CONTENTS

PART III

OPERATIONS ON THE HEAD, NECK AND SPINE

PART IV

OPERATIONS ON THE THORAX AND BREAST

PART V

OPERATIONS ON ARTERIES, VEINS AND NERVES

PART VI

AMPUTATIONS

PART VII

OPERATIONS ON BONES AND JOINTS

PART VIII

OPERATIONS ON TENDONS, INCLUDING THE DIVISION OF CONTRACTED MUSCLES, LIGAMENTS AND FASCIÆ

LIST OF PLATES

A MANUAL OF

OPERATIVE SURGERY

PART III.—OPERATIONS ON THE HEAD, NECK AND SPINE

CHAPTER I

OPERATIONS ON THE SKULL AND BRAIN

THE operations dealt with in this chapter include those on the soft parts, such as the removal of tumours originating in those parts; removal of parts of the calvarium, either because, as in cases of depressed fracture, their presence is leading to symptoms, or to lessen the pressure on the brain due to new growths, themselves inaccessible or irremovable; opening of the calvarium for the purpose of removing extradural collections of pus or blood; operations upon the brain proper after opening the dura mater (these include evacuation of abscesses within the cerebrum and cerebellum); the removal of cerebral tumours; drainage of the lateral ventricles, either temporarily or permanently; the removal of foreign bodies, such as bullets; and the excision of diseased nerve centres, such as parts of the motor area in cases of Jacksonian epilepsy.

Here are also included operations upon the ear and its accessory sinuses, such as the mastoid, and those devised for the relief of conditions arising from diseases of the ear.

Lastly, we deal here with those operations which are undertaken in cases of disease of the frontal sinuses and the antrum of Highmore.

Anatomical Points.—*Position of the Sutures.*—The bregma, or point of junction of the coronal and sagittal sutures, is in a line drawn vertically upwards from a point just in front of the external auditory meatus, the head being in normal position. The lambda, or point of junction of the lambdoid and sagittal sutures, lies in the middle line, about two inches and three-quarters above the occipital protuberance. The lambdoid suture is fairly represented by the upper two-thirds of a line drawn from the lambda to the apex of the mastoid process.

The coronal suture lies along a line drawn from the bregma to the middle of the zygomatic arch. On this line, at a spot about on a level with the external angular process of the frontal bone, and about one inch and a half behind that process, is the pterion. The summit of the squamous suture is one inch and three-quarters above the zygoma (Fig. 194).

The *thickness of the skull* varies greatly, not only in different parts of the same skull, but also in corresponding parts in different individuals. The average thickness is one-fifth of an inch. The thickest parts are at the occipital protuberance (where the section may measure half an inch), the mastoid process, and the lower part of the frontal bone. The bone over the inferior occipital fossæ is very thin, while it is thinnest at the lower part of the temporal fossa. Here the bone may be no thicker in parts than a visiting-card. The skull is also thinned over the sinuses and the grooves for the meningeal vessels. It is important to remember in trephining that the inner table is not always parallel with the outer.

The *middle meningeal artery* is a frequent source of bleeding after fracture of the skull. This vessel, having passed through the foramen spinosum, divides into two branches; the anterior —the larger—runs upwards across the anterior inferior angle of the parietal bone; the posterior runs backwards, with a horizontal sweep, across the squamous bone. Their position may be marked on the surface, as follows: For the anterior branch a point one and a half inches above Reid's base line and one and a half inches behind the fronto-malar point, which point can be easily felt about $\frac{1}{4}$ inch above the commencement of the zygoma. For the posterior branch, either a point one inch above the external auditory meatus, which lies over the

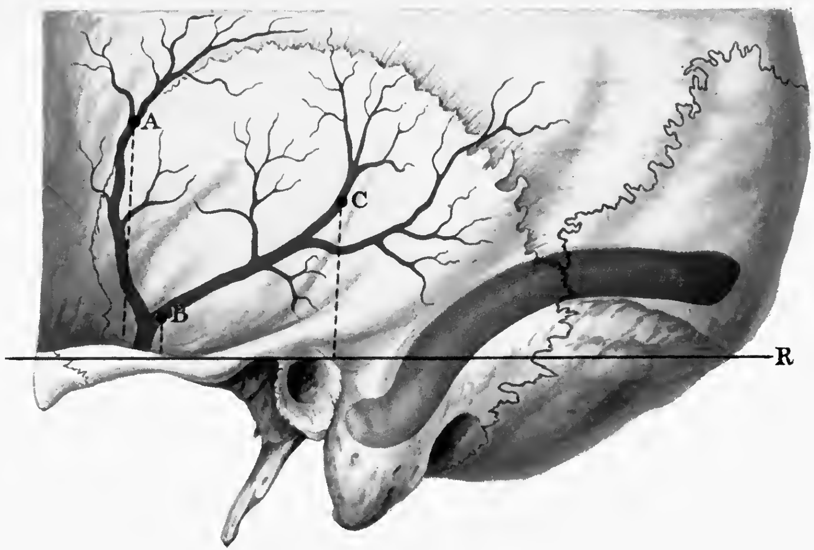

PLATE XVIII.—POSITION OF THE BRANCHES OF THE MIDDLE MENINGEAL ARTERY.

R., REID'S BASE LINE. A, ANTERIOR BRANCH, $1\frac{1}{2}$ INCHES BEHIND THE PONTO-MALAR POINT, AND $1\frac{1}{2}$ INCHES ABOVE REID'S LINE. B, POSTERIOR BRANCH ORIGIN, $1\frac{3}{4}$ INCHES BEHIND THE PONTO-MALAR POINT, AND $\frac{1}{4}$ INCH ABOVE REID'S LINE. C, POSTERIOR BRANCH IN ITS POSTERIOR PART, 1 INCH ABOVE THE EXTERNAL AUDITORY MEATUS.

posterior part of the artery just before it divides, or a point one and three-quarter inches behind the fronto-malar point and a quarter inch above Reid's base line ; this lies over the anterior part of the artery close to its origin from the common stem (Fig. 218, page 69).

The branches of the artery are more frequently ruptured than

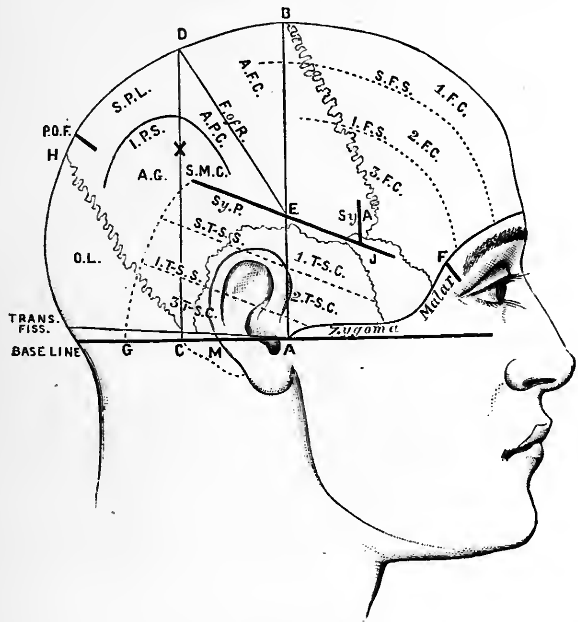

FIG. 194.—DIAGRAM TO SHOW THE RELATIONS OF THE BRAIN TO THE SKULL.

(*Modified from Reid.*)

J.B, Coronal suture ; B, Bregma ; F, External angular process ; H, Lambda ; H.C, lambdoid suture ; J, Pterion ; M, Mastoid process ; X, Parietal eminence ; Sy.A, Sy.P, Anterior and posterior limbs of Sylvian fissure ; F. *of* R, Fissure of Rolando ; A.F.C, A.P.C, Ascending frontal and ascending parietal convolutions ; S.F.S, I.F.S, Superior and inferior frontal sulci ; 1 F.C, 2 F.C, 3 F.C, Frontal convolutions : S.T-S.S, I.T-S.S, Superior and inferior temporo-sphenoidal sulci ; 1 T-S.C, 2 T-S.C, 3 T-S.C, Temporo-sphenoidal convolutions ; I.P.S, Intraparietal suture ; S.P.L, Superior parietal lobule ; S.M.C, Supermarginal convolution ; A.G, Angular gyrus ; P.O.F, Parieto-occipital fissure ; O.L, Occipital lobe. *See also* text.

the trunk, and a laceration of the anterior one as it crosses the lower and front angle of the parietal bone is the most common.

Relations of the Brain to the Skull.—In dealing with troubles involving the brain, very precise localisation is essential. Many methods of marking out the different parts of the brain have been invented ; but it is important that the method used should

be one as easy to remember as possible, and one which does not involve the use of complicated measurements and angles. A perfect method is impossible owing to the variations in individual heads, but the area aimed at must lie within the circle made by a small trephine having as its centre the point of localisation.

The line of the convolution required may be marked out on the scalp before operation. The scalp having been shaved all over, the position of the convolution is determined by one of the methods given below, and the line marked on the scalp with a 5 per cent. solution of silver nitrate, which may, after drying, be darkened with a solution of oxalic acid. This will give a permanent marking which will not be destroyed by the methods adopted for sterilising the scalp. When the patient is anæsthetised the desired point may be marked on the bone by driving a small sterilised bradawl through the skin; the small depression thus made in the bone is easily found when the flap is reflected.

The diagram shown in Fig. 194 depicts the relations of the chief sutures and convolutions, as defined by Dr. Reid. As in the following pages allusion will often be made to "Reid's base line," it may be said that this is a line drawn across the skull from the inferior margin of the orbit backwards through the centre of the external auditory meatus (Fig. 194). The relations of the different bones of the skull to the underlying parts of the brain are shown in Fig. 195.

The positions of the two great fissures may be indicated.

The Fissure of Sylvius.—A line is drawn from a point one inch and a quarter behind the external angular process (Fig. 194, F) to a point three-quarters of an inch below the most prominent part of the parietal eminence (X). The first three-quarters of an inch of the line will represent the main fissure, and the rest of the line will indicate the horizontal limb. The ascending limb will start from the anterior end of the line indicating the main fissure, and run vertically upwards for about one inch (Fig. 194, SY.A).

The Fissure of Rolando.—From the base line draw two vertical lines upwards—one (Fig. 194, A B) from the depression in front of the meatus, and another (C D) from the posterior border of the mastoid process at its root. There is thus formed a four-

sided figure, bounded above and below by the median line and the horizontal limb of the Sylvian fissure respectively, and in front and behind by the two vertical lines. A diagonal line (D E) drawn from the posterior superior angle to the anterior inferior angle of the space will be over the fissure of Rolando.

The fissure of Rolando may also be determined in the following manner: Join the point at the depression at the root of the nose with the external occipital protuberance along the

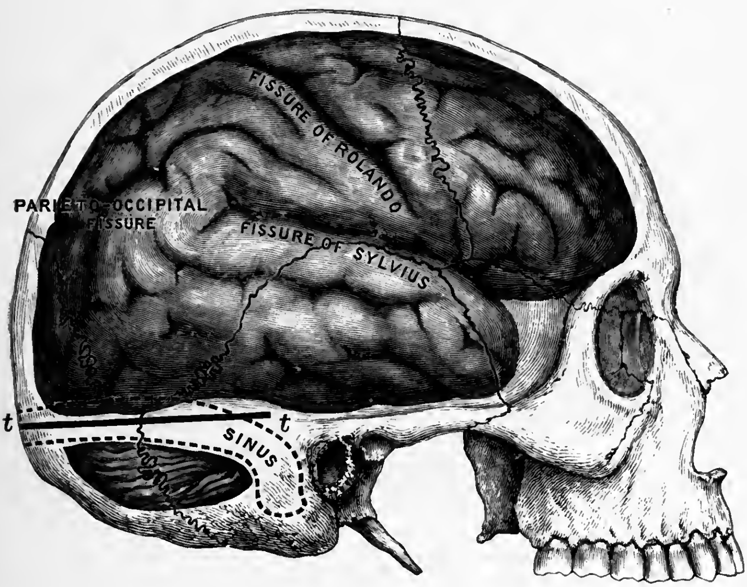

FIG. 195.—SHOWING RELATIONS OF THE BONES OF THE SKULL TO THE BRAIN, LATERAL SINUS AND TENTORIUM CEREBELLI.

t t, Line of attachment of the tentorium to the inner surface of the skull.

median line, find the mid-point with a piece of sterilised ligature, mark a point half an inch behind this. This will correspond to the upper end of the fissure, which runs at an angle of 67·5 degrees (three-fourths of a right angle) downwards and forwards.

The situation of the chief convolutions is indicated in Figs. 194, 195 and 199.

Cerebral Localisation.—The localisation of a lesion within the brain is not always possible. The functions of many portions of the brain are at present quite unknown; and in others,

the so-called silent areas, a large destructive lesion may exist without giving rise to any symptoms which will point to its position. Lesions in the following areas can, however, often be accurately localised :—

1. *Motor Areas.*—Into the open question as to whether there really be true motor centres in the cerebral cortex, it is not our place to enter here. It is sufficient for the purposes of practical surgery that there are parts injuries to which are constantly followed by motor changes in the peripheral areas, these areas varying only with the portion of cortex that is affected,

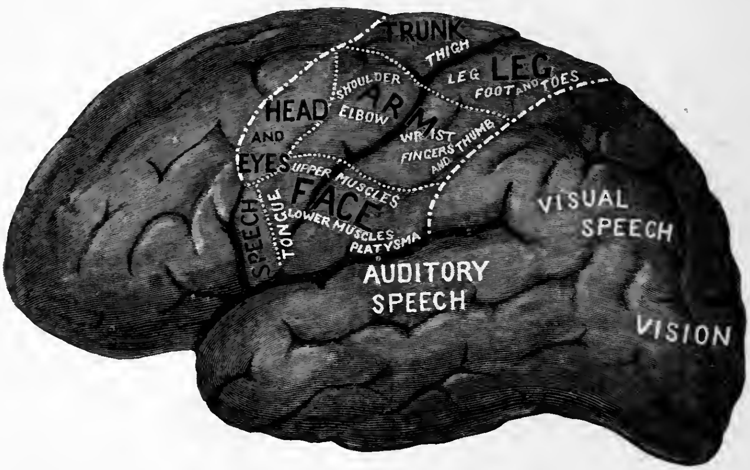

FIG. 196.—OUTER SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING SENSORI-MOTOR AREA, SPEECH AREAS, AND VISUAL AREA.

so that by observing local paralyses, spastic contractions, or spasmodic movements, the position of lesions within the cortical area may be determined with a fair degree of accuracy.

These areas are known as the motor centres and are grouped around the fissure of Rolando, the position usually accepted being that of Figs. 196 and 197 ; but in light of recent work by Sherrington and Grünbaum (*Trans. Royal Soc.*, 1901, vol. lxix.) it is doubtful if these be correct ; the position given by them is that shown in Figs. 198 and 199. These observations were made in the higher apes, but it is probable that they apply to man also.

A localised paralysis or spasticity indicates a limited lesion,

and usually one in the cortex, the fibres in the internal capsule being more closely aggregated. In cases of irritative lesions, spasmodic movements (Jacksonian epilepsy) will commence in that part corresponding to the motor centre affected, but may soon spread to other parts, until the whole body is involved and even unconsciousness produced. In such cases, however, the part first affected always corresponds to the injured centre. Paralysis, or spasm of the arm, indicates a lesion in the ascending frontal convolution about its middle, on that side of the brain opposite to the affected arm. If the lower limb be affected,

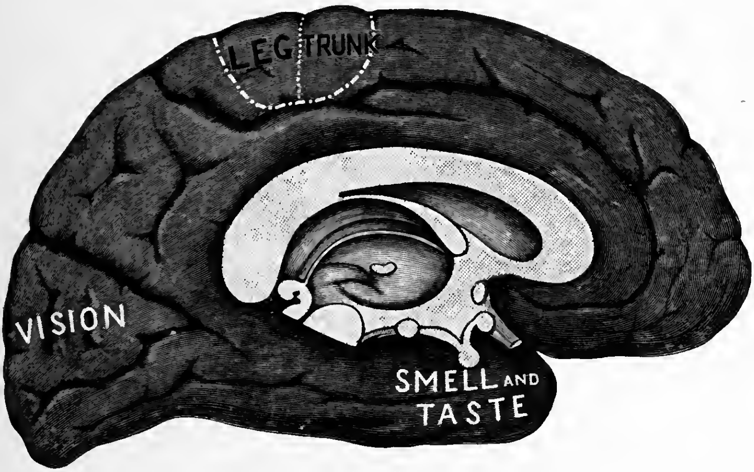

FIG. 197.—MESIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING SENSORI-MOTOR AREAS FOR LEG AND TRUNK, AND THE AREAS FOR VISION AND FOR SMELL AND TASTE.

the lesion is in the upper portion of the ascending frontal convolution; and hence a trephine should be applied just in front of the upper part of the line marking out the fissure of Rolando. Paralysis of the face and neck points to a lesion of the lower part of the ascending frontal convolution.

In many cases larger areas may be affected, so that the trephine hole must be enlarged; but the primary opening should be made over the cortical area corresponding either to the part most affected or first affected if paralysed, or to the part in which the spasms commence, if there be Jacksonian epilepsy.

2. *Speech Centres.*—The cortical areas concerned in speech are situated on the left side of the brain, and are four in number —viz. the auditory speech, the visual speech, the motor speech, and the motor for writing. Their positions are indicated in Fig. 196. The symptoms arising from simple or compound lesions of these areas, together with their connecting fibres, is too complex a matter to be discussed here. It is sufficient to state that a lesion localised to the motor speech centre (Broca's area) in the left inferior frontal convolution is associated with loss of speech, the patient being still able to hear, see, and write.

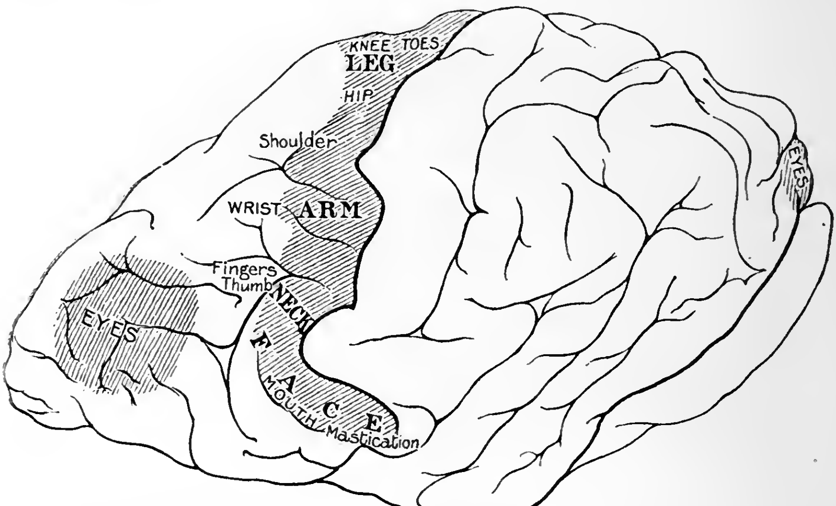

FIG. 198.—THE CENTRES IN THE CHIMPANZEE ACCORDING TO SHERRINGTON AND GRÜNBAUM.

For further information on this subject Bastian's article on aphasia should be consulted ("Aphasia and Other Speech Defects," 1898).

3. *Cerebellum.*—This is chiefly affected in cases of abscess secondary to otitis media or mastoid disease. Lesions of one lateral lobe affect the corresponding side of the body, whilst lesions of the middle lobe affect both sides. Lesions of one lateral lobe may, however, give no localising signs, and cases of congenital absence of one lobe have occurred with no symptoms pointing to the abnormality.

The symptoms are definite. Trotter (*Brit. Med. Journ.*, March 14th, 1908) classifies them as follows :—

Ocular signs.	*Signs affecting the limbs.*
Nystagmus.	Inco-ordination.
Weakness of conjugate movements.	Paresis.
Skew deviation.	Hypotonicity.

Nystagmus.—This is a common symptom, being more often found in the case of tumours than of abscess. Thus in Ferrier's list of 41 cases it occurred in 24. It is usually lateral.

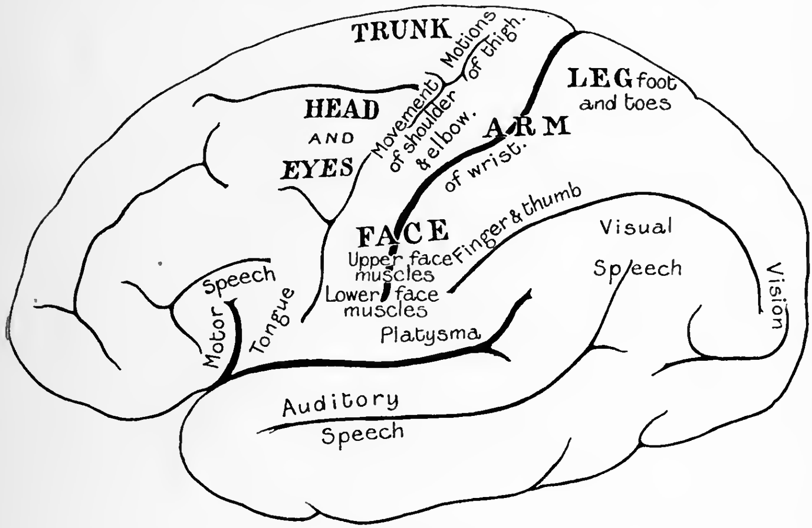

FIG. 199.—THE CENTRES IN MAN ACCORDING to SHERRINGTON AND GRÜNBAUM. (*Compare Fig.* 196.)

Conjugate movements are not only weak, but there is often conjugate deviation towards the opposite side.

Vertigo.—This is one of the commonest symptoms. The patient may feel either that his body or the surrounding objects are revolving. Krause (quoted by Osler) gives this symptom as present in 48 out of 100 cases.

Inco-ordination is marked on the same side of the body as the lesion. Thus there may be loss of power to perform rapidly the movements of supination and pronation, and inability to perform flexion and extension of the limbs with rapidity and accuracy. With this there is *ataxia,* which resembles that

induced by alcohol, the patient walking with a wide base and tending to fall towards the side of the lesion.

Paralysis occurs on the same side as the lesion, is not associated with spasticity, does not involve the face and chiefly affects the coarser movements. The reflexes are as a rule not increased.

Headache, vomiting, optic neuritis, a slow pulse, and a *lowered temperature* may occur as with any intracranial lesion causing pressure.

Lesions in the occipital lobe may give homonymous hemianopsia.

I. OPERATIONS FOR TUMOURS OF THE SCALP, CRANIAL BONES, AND DURA MATER

Sebaceous Cysts.—These are common on the scalp, and may require removal, either from the deformity they produce, or the inconvenience (especially in wearing a hat), or because of complications. They may be readily removed by making an oval incision over them; the cyst, together with the overlying and attached piece of skin, is then dissected out and the edges of the skin are sutured together. This method is much preferable to that of transfixing the skin and then pulling the wall out with forceps, for by this means the wound is likely to become infected from the septic material within the cyst.

Dermoid Cysts.—Sequestration dermoids are most common over the external angular process, the root of the nose, or over the fontanelles. An oval incision should be made over them, and the cyst dissected out, any prolongation through a cavity in the bone being carefully ligatured.

Molluscum Fibrosum (Pachydermatocele of the Scalp).—The tumours may grow to a great size, producing marked deformity, for which removal may be desired. They must be widely excised, as recurrence is common. The hæmorrhage is likely to be considerable, but may be controlled by means of a tourniquet applied round the skull, above the level of the eyes. As it may be impossible to bring the edges of the wound together, Thiersch's method of skin grafting may be required at a later date.

Nævi.—Capillary nævi are common on the scalp in children.

They are important in that when occurring over the anterior fontanelle they may grow to a considerable size and extend to the dura mater. When small they may be easily excised. If large they are best treated by electrolysis, and it is preferable not to commence this until after the anterior fontanelle has closed, using then only a weak current.

Cirsoid Aneurysm and Aneurysm by Anastomosis.—The scalp is a favourite position for these aneurysms, especially in the auriculo-temporal and frontal regions. Their treatment is beset with much difficulty, the smallest incision being immediately followed by alarming hæmorrhage. If possible, they are best excised. The excision should take place with an elastic tourniquet around the skull just above the level of the eyebrows. In the majority of cases, however, they extend so low down that this cannot be applied. In such a condition a preliminary ligature of the external carotid on the affected side should be done, and in excising the aneurysm the main arteries running to it should be first exposed and ligatured. Where the aneurysm is situated in the frontal region hæmorrhage is much less controlled by ligature of the external carotid. In these cases all attempts at excision may have to be abandoned.

Wyeth (*Journ. Amer. Med. Assoc.*, June 27, 1903) has introduced a method of injecting boiling water into the vessels, whereby they become occluded. He has reported several cases, and others have also been recorded where good results have followed. Whether the method is free from danger of embolism cannot yet be said, but in a condition so difficult to deal with by usual surgical methods, it is well worth careful trial. If the arteries supplying the growth can be felt the water should be injected along their course; where it is superficial, beneath the growth, so as to lessen the possibility of sloughing. Obliteration of the whole growth at one sitting should not be attempted.

Exostoses.—Cancellous exostoses are readily removed, and require no special mention. The ivory variety occur most commonly, either in the region of the external auditory meatus—and may, indeed, lead to occlusion of this, with consequent deafness—or within the frontal sinus.

If within the meatus they may be reached by reflecting the

ear forwards, and their removal brought about by the electric burr. They are usually too hard to divide readily with the chisel, and if this instrument be used too forcibly the skull may be fractured.

When within the frontal sinus, the anterior wall of this structure must be freely removed with a chisel or small trephine, and the limits of the growth having been determined, its root may again be divided with the electric burr. In cases it may be necessary to remove the posterior wall of the sinus, portions of the ethmoid, and part of the roof of the orbit. In some cases the eyeball itself may have to be sacrificed.

Sarcomata.—These may originate in the periosteum, the bone, or the dura mater. Except in the early stages they can only be distinguished from one another with difficulty. Those arising in the dura usually lead to erosion of the bone, so that the edges of the cavity have a sharp edge ; moreover, when they perforate, the symptoms of intracranial pressure may largely abate. In the central and periosteal growths, on the other hand, there is often new formation, leading to the so-called dilatation of bone ; and even when this has become eroded, a bony wall may be felt at its base rising up above the level of the skull. In either case they grow rapidly and give rise to early secondary deposits. They are very vascular, and may pulsate, and hence a vascular central or periosteal growth may simulate one of the dura, with transmitted pulsation from the brain.

No operation should be undertaken unless the opportunity arise quite early, for not only are the growths very rapid, but in many cases a small growth on the outer surface may be associated with a large mass between the bone and dura, or it may involve or have perforated the dura, so that a portion of this may have to be removed. The hæmorrhage is always severe, and as it may largely come from dilated vessels in the diploë or meninges, it is often difficult to control. The operation is extensive, a large amount of bone having to be removed ; and in many cases, owing to the condition of the patient, operations have been unable to be completed. Liability to local or visceral recurrence is great.

The patient is carefully prepared, to guard as far as possible against shock, and the head is shaved and made as aseptic

as practicable. If the skin be free a large flap should be made and turned downwards. The subsequent procedure will depend largely upon the condition found. If the bone is perforated and the growth is small, it will probably be found best to remove the projecting portion, and then to enlarge the opening in the bone with Hoffmann's forceps, until healthy bone is seen or the limits of any underlying mass of growth are reached; it being remembered that the growth is liable to spread further along the diploë than on the surface of the bone. In that case it is removed, the dura, if healthy, being left untouched, but if showing the slightest suspicion of being infiltrated it must also be removed. Should there be no opening in the bone, or if the growth is quite localised and with no symptoms of intracranial trouble, it may be preferable to surround it with small trephine holes, and, by joining these by means of a Gigli's saw, to remove *en masse* the whole growth and affected bone. In such cases it is usually unnecessary to do anything to fill up the hole left in the bone, for provided that the dura is left uninjured, the new bone, which rapidly forms, is generally sufficient to occlude it.

Epitheliomata.—These, when arising on the scalp, may, if not dealt with early, infiltrate the underlying bone and dura mater, and in some cases the brain itself. If not too extensive, and there is no evidence of secondary deposits, they may be dealt with in a manner similar to that described above.

2. THE OPERATIVE TREATMENT OF FRACTURES OF THE SKULL

Indications for Operation.—Three varieties of fractures of the vault of the skull have to be considered. These are—

(1) Compound depressed fractures
(2) Simple depressed fractures
(3) Punctured fractures

(1) *Compound Depressed Fractures.*—In all these cases, whether there be any symptoms of compression or not, operative treatment must be undertaken, the depressed area of bone elevated, and its inner surface, together with that of the neighbouring bone, investigated. The operation should be

immediate—that is to say, no long interval should be allowed to elapse during which the surgeon awaits the onset of symptoms. The reasons for this are as follows :—

(*a*) It is not possible to determine from an examination of the outer table what may be the damage to the inner table or the dura mater. In the majority of cases the disturbance to the inner table is greater than that to the outer (*see* Figs. 200, 201) ; and although this damage may be insufficient at the time of operation to cause symptoms, it may irritate the surface of the cortex and thus lead to a slow sclerosis, followed in time by Jacksonian epilepsy, chronic irritation, or insanity, the nature

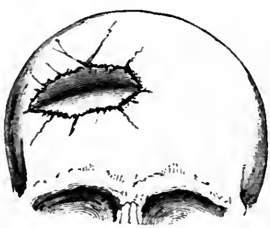

FIG. 200.—GUTTER FRACTURE OF THE SKULL. (*Hutchinson.*)

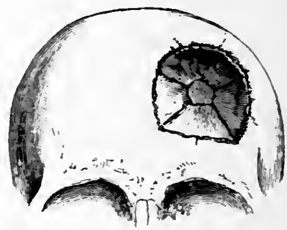

FIG. 201.—POND FRACTURE OF THE SKULL. (*Hutchinson.*)

of the lesion being such that a future operation is unlikely to hold out much hope of relief.

(*b*) The sepsis which is invariably present cannot be adequately dealt with unless the depressed fragments be elevated. In many cases the fragments are driven in and then rebound to a large extent, so that particles of foreign and septic bodies become firmly impacted between the edges ; the ends of these may even project on to the dura mater, so that unless they be removed sepsis within the diploë or between dura mater and bone is very likely to follow. It may even be necessary for this reason to remove pieces of bone in cases of compound *fissured fracture*, and there should be no hesitation in pursuing this course in such cases, when simpler methods have failed to remove impacted hair or other septic material.

(*c*) Although the injury to the inner table may at the time of the accident be small, being perhaps a mere fissure or irregularity, yet in the process of union the newly formed bone may be irregular,

excessive, or even osteophytic in nature, and after several months or years may lead to signs of local irritation.

Wagner (quoted by Jacobson, "Operations of Surgery," 1907, p. 241, vol. i.), gives the mortality of immediate trephining as 1 in 23, that of trephining after twenty-four hours as 1 in 3.

(2) *Simple Depressed Fractures.*—In some of these cases the indications for operation are not quite so clear. If symptoms of compression or long-continued concussion be present, there will, of course, be no hesitation, and early operative interference will be adopted; in other cases, where there are no signs of pressure, it will be found best for the reasons given above that an operation should be undertaken in all cases where the portion of bone depressed is sharply broken off, or is limited in size, or is tilted—in fact, in all cases of simple depressed fracture, excepting only those which are described as pond or saucer shaped, and provided only that these occur in young children and are giving no signs of pressure, for in such cases the bone is soft and membranous, and the lesion consists of an inward bulging rather than a fracture, there being no inwardly projecting sharp points of bone; and in many of these it will be found that the lesion is reduced spontaneously in the course of a few days. Should signs of pressure or irritation develop, the depressed area must be elevated by surgical procedures. Such a case as is depicted in Fig. 201 would require operation. Here the edges of the depression are sharply broken off, and symptoms either immediate or remote would be certain to follow if the condition were left untreated.

FIG. 202.—INNER SURFACE OF SPECIMEN SHOWN IN FIG. 201.

(3) *Punctured Fractures.*—These include punctured fractures of the vault, produced usually by some sharp instrument, and punctured fractures of the base. Those of the vault must in

all cases be operated on, however small the wound in the soft tissues and outer table of the bone may appear, and however free from symptoms the patient may be. No other course is permissible. The amount of damage to the inner table is nearly always in excess of that to the outer table. There may have been injury to the underlying brain, and portions of the instrument causing the damage or of septic material coating it may have been left behind. Fractures of the base, such as punctures of the anterior fossa through the orbit or nose, or of the middle fossa through the temporal region, are usually associated with depressed portions of bone, and in nearly all cases are followed by septic symptoms, either of which may require operative treatment. In many such the symptoms are at first trivial, and the wound of entry is situated at some considerable distance from the site of the fracture, so that until complications arise, indications for operation may not be present. Several such cases showing the difficulty in diagnosis have been reported by Mr. Knaggs (*Lancet*, June, 1907).

Preparation of the Patient.—Here must be said a few words on the treatment of compound fractures of the skull when they first present themselves. The wound in the scalp must not be immediately explored with probe or finger, as is so often done. It must be lightly plugged with gauze, and the skin around carefully shaved and cleansed, special attention being paid to the edges of the wound. The gauze is then removed and the wound itself carefully cleansed out with 1—40 carbolic. All loose particles of skin and foreign matter and any hair being carefully removed, then, and not until then, the depths of the wound may be carefully explored, preferably with the cleansed finger, for the presence and extent of the fracture. If a fracture be present the patient is anæsthetised, a larger area of the scalp is carefully shaved, it often being necessary to remove the hair from one half or more of the head. The wound and surrounding tissues are again thoroughly cleansed, and if the edge of the tissue be much bruised it is cut away. Few wounds in the body so well repay care in this matter, lacerated areas filled with septic material often, probably owing to the vascularity of the part, uniting after such treatment by primary union.

In operations that are not of an urgent character the usual antiseptic compress should be worn for some twelve hours before the operation. Such preparation is possible in most cases of operation upon the brain.

The head is conveniently supported upon a sand-bag covered with macintosh sheeting and sterilised towels.

Chloroform will probably be the anæsthetic selected.

Operation.—The patient having been anæsthetised, and prepared as above, the wound, if large, is opened up and deepened so as to divide the pericranium throughout its whole length; this, together with the soft parts, is reflected from the bone. If the wound be small—and, in fact, whenever possible—a flap, with its base below, should be made.

The incision should be carried at once down to the bone, and the pericranium having been detached with a curved rugine,

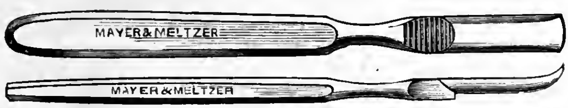

FIG. 203.—PERIOSTEAL RUGINE, BACK AND SIDE VIEWS.

the flap as it is turned up will be composed of all the soft parts covering the skull.

A long suture should be inserted into the free end or apex of the flap, and by means of this thread the flap is drawn down, and held out of the way.

The bleeding from the scalp tissues is usually free. The more conspicuous bleeding points are neatly secured by pressure forceps; sponge pressure will check mere oozing.

The fracture is now exposed and examined. It may be found to be at once possible to introduce an elevator beneath the depressed bone and raise it. Fragments at the same time may often be readily removed by means of dressing forceps or necrosis forceps.

In other cases a rim of projecting bone—belonging to the sound part of the skull—may be removed with a narrow chisel and mallet, or with Hey's saw, or with the gouge or gouge-forceps, and a little space is at once provided between the bones which will allow of an elevator being introduced. In this part of the

operation it must be confessed that Hey's saw is of little use. Indeed, Hey's saw is not a serviceable instrument, and it is rarely employed.

The elevator must be introduced with care. It is apt to slip, and such an accident is least possible with Horsley's instrument (Fig. 204). In raising the depressed bone, it is needless to say that the elevator must be supported upon the sound part of the skull.

Sometimes when the bone is much comminuted one fragment will be found to be so tilted outwards that it can be seized and removed, and through the gap thus left the elevator or the blade of the dressing forceps or necrosis forceps can be introduced.

In a comparatively few cases the trephine (Fig. 205) will be needed. The centre-pin of the instrument is introduced; the crown is then applied to the sound bone near to the

FIG. 204.—ELEVATOR FOR THE SKULL, WITH HEEL WHICH ACTS AS A FULCRUM. (*Sir Victor Horsley's pattern.*)

fracture. As a rule, it is so applied that two-thirds or three-fourths of the circle will be upon the sound skull, and the remaining third or fourth over the fractured area. The trephine should not be placed so far over the injured area as to produce trouble by jarring any fragment which may be lying in contact with the dura mater.

The point is bored into the bone, and then the trephine is made to cut into the skull by light sharp movements from left to right, and from right to left.

At first the instrument may be steadied by the left forefinger, which rests upon the skull. As soon as a groove has been cut all round, the pin may be withdrawn, and the instrument will be found to maintain a steady hold of the part. The pressure must be evenly maintained throughout, and will be found to be chiefly exercised when the hand is turned from left to right (the supination movement). At first the bone-dust is dry, but as soon as the dense outer table is cut through it becomes

soft and bloody. As the trephine enters the diploë the softer character of the resisting medium is at once recognised.

The wound in the bone must be kept constantly clear of dust by frequent irrigation and the use of the quill. The trephine itself is rinsed in warm sterilised water from time to time, to free it from *débris*. Those who have only experimented with the dry skull of the cadaver will be surprised at the ready manner in which the trephine cuts its way into the living bone. The depth of the groove in the skull must be estimated from time to time with the quill, or Horsley's seeker (Fig. 206). Inasmuch as the skull is spheroidal, it is exceedingly difficult to make the groove of equal depth all round. The shallower parts must be specially cut down to the level of the deeper parts, by pressure upon the bone at the points where the division has been less complete. As the inner table is penetrated, increased caution must be exercised, and still more care is needed when once the groove has been extended right through the skull. It must be remembered that the bone will probably be of unequal thickness even over the small area covered by the trephine.

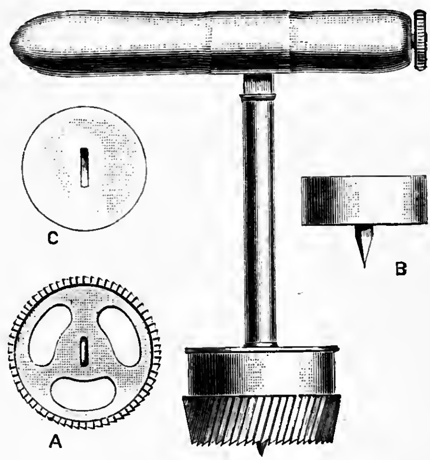

FIG. 205.—MODERN ASEPTIC TREPHINE.

A, From below, with pin removed; B, The pin; C, Upper surface of the pin, showing a small depression to fit into the elevation shown in A (in order to fix the pin).

When the groove is of sufficient depth, the disc of bone may be removed by gently rocking the trephine to and fro while it is still in position, or by cautiously introducing an elevator at a spot where the bone is entirely divided. Not infrequently the disc of bone can be grasped with forceps, and lifted out. In any case, some little portion of the inner table will have to be broken through.

Should any portions of the inner table be left behind, they can be removed by the elevator or the cutting gouge.

In removing large discs of bone it is important that the dura mater be carefully stripped from the inner table as the button is being cautiously lifted up with the elevator.

The trephine disc, if it is to be replaced, may be at once put in a china receptacle containing a warm solution of corrosive sublimate (1 in 2,000), or saline, and maintained at a temperature of 100° F. In the majority of cases, however, it is preferable to make no attempt to replace the removed bone. It is surprising to what an extent new bone is formed in this situation, and in a case operated on by one of us nearly two square inches of bone were removed, yet at the end of two months the tip of the little finger could not be inserted into the resulting cavity. Moreover, the after-complications due to excessive bone formation are less likely to occur if the bone be not replaced. Any septic infection from the depressed bone will also be prevented.

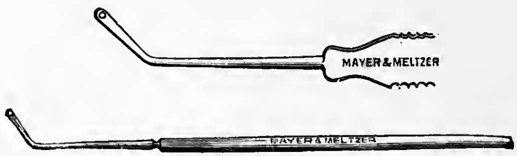

FIG. 206.—HORSLEY'S SEEKER.

In the case of a punctured fracture it is well to employ an inch trephine, and to let the pin of the instrument fall near to the puncture, in order that the whole of the damaged area may be removed, and the possibly wide-spreading comminution of the inner table be fully exposed. This particularly applies to the fracture caused by the points of entry of a small calibre bullet such as the Mauser. The aperture of exit of such missiles will, as a rule, not need the trephine.

If in any case the hole made is not sufficient for the purpose, it may be enlarged by means of the rongeur, the chisel, or a fresh application of a smaller trephine to an adjacent segment of bone.

In all cases every splinter and loose fragment of bone must be cautiously removed. Depressed fragments which still retain

a hold upon the sound bone are left in position after they have been elevated.

The edges of the opening in the bone are finally smoothed off with the rongeur or the gouge.

The treatment of any hæmorrhage that may arise is dealt with on page 27.

The trephine disc or any large fragment of bone which has been preserved may be replaced as nearly as possible *in situ*.

The flap or flaps of scalp are now brought into place by silkworm-gut sutures,

FIG. 207.—HOFFMANN'S FORCEPS.

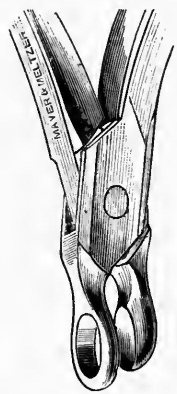

FIG. 208.—HORSLEY'S MODIFICATION OF HOFFMANN'S FORCEPS.

and drainage is secured by a slight gauze drain or tube. The skin is well cleansed, the wound is dusted with iodoform, and a suitable dry dressing is applied and is secured by means of a tight flannel bandage.

Complications.—When the dura mater has been wounded, it should be carefully sutured with the finest catgut whenever possible.

Hæmorrhage throughout the course of the operation may be

free, but it seldom gives much trouble. Oozing from the diploic, as a rule, soon ceases spontaneously. Should one of the diploic veins have been cut across, and bleed persistently, in spite of sponge pressure, a little of the bone tissue around the divided vessel may be crushed into the mouth of the opening by means of the point of an elevator. Bleeding from the dura mater, if obstinate, may need to be checked by a fine catgut ligature. The vessel will have to be picked up, most probably by means of a ligature on a small curved needle.

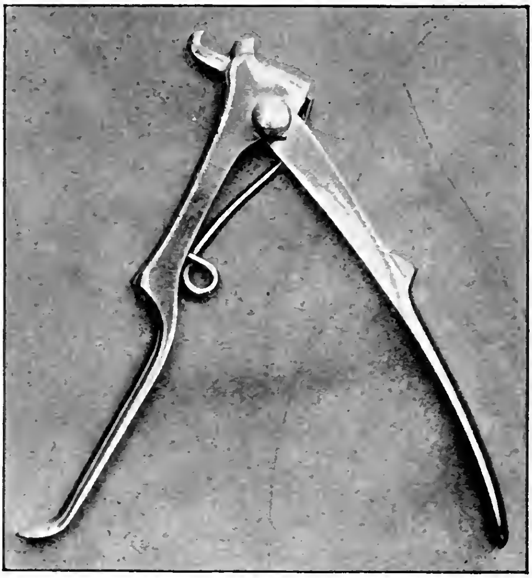

FIG. 209.—DE VILBISS' RONGEUR.

Hæmorrhage from the middle meningeal artery is dealt with on page 24.

If bleeding take place from a sinus, pressure should at once be applied by means of a piece of aseptic gauze. Mr. Jacobson points out that bleeding from even a large venous sinus is readily arrested by quite moderate pressure. The gauze may need to be kept in position for some time, and in extreme cases has been left *in situ* for two or three days. In several instances hæmorrhage from a sinus has been arrested by lateral ligatures, and cases are recorded in which lacerations of both the superior longitudinal

sinus and the lateral sinus have been successfully treated by this means.

"Certain precautions must be observed," writes Dr. Nancrede, "when the fracture is near a sinus which we suspect has been wounded by depressed fragments. Thus the trephine-cut must be planned so as to give access to any bleeding point rather than merely to admit easy elevation of the fragment. One is often tempted to draw out a long fragment driven some distance beneath sound bone, whose concealed extremity lies in close proximity to a large sinus, possibly wounding it. . . . In such case it is far safer to trephine over the site of the concealed extremity of bone, when, if its withdrawal is followed by hæmorrhage from a wound of the sinus, instant compression may be effected."

When in certain cases—probably cases of operation for disease—it appears imperative to trephine over a sinus, two smaller trephine discs should be removed from either side of the sinus, and the intervening bridge of bone be then cautiously cut away.

In cases of punctured wounds of the base the wound must be carefully opened up and explored, any foreign particles being removed. When the fracture is accessible, any depressed spicules of bone must be elevated and removed. Where the puncture has taken place through the orbit this may be best accomplished by trephining above the orbital ridge and reflecting the dura mater upwards. The loose pieces of bone may be thus readily removed, and any collection of pus evacuated. If there be any injury to the dura itself this may be dealt with through the same opening. Attempts should be made to render the cavity aseptic, and the wounds should be drained.

The **after-treatment** is considered on page 44.

3. THE OPERATIVE TREATMENT OF INTRACRANIAL HÆMORRHAGE

The whole subject of hæmorrhage from the middle meningeal artery has been thoroughly dealt with by Mr. Jacobson in a most able article published in the *Guy's Hospital Reports* for 1886. In the majority of cases the hæmorrhage occurs from the middle meningeal artery. Thus Prescott-Hewett (Holmes's "System

of Surgery," 1883) found that of 31 cases of hæmorrhage 27 were due to injury of this artery. The position of the extravasated blood is shown in Fig. 210.

Indications for Operation.—When hæmorrhage from the middle meningeal artery is diagnosed an operation must be undertaken ; hence the indications are the presence of those symptoms usually associated with such a condition. When a blow upon

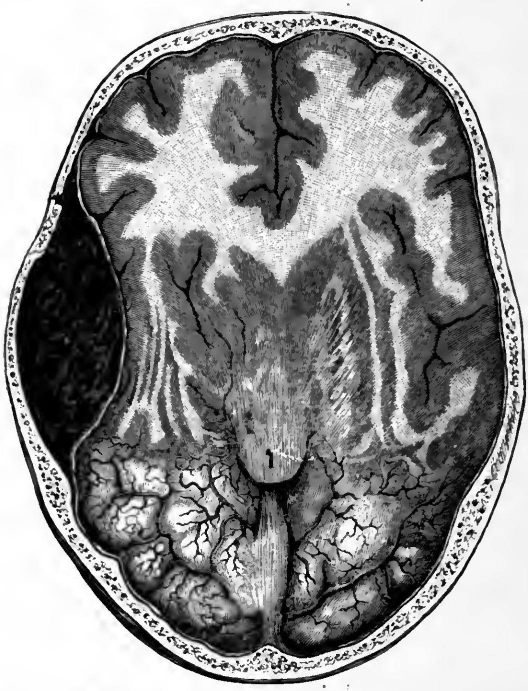

FIG. 210.—RUPTURE OF MIDDLE MENINGEAL ARTERY OF THE LEFT SIDE IN A CASE OF FRACTURED SKULL. THE BLOOD-CLOT IS LYING BETWEEN THE DURA MATER AND THE BONE. (*Hutchinson.*)

the head is followed by rupture of this artery, there is a period of concussion, followed by a lucid interval, the patient then passing into a state of compression. This lucid interval, if present, is very characteristic, but it is often absent ; the presence of a lesion upon the temporal region, associated or not with fracture, and followed with a gradual onset of compression ; the presence of increasing mono- or hemiplegia ; unequal pupils (that on the affected side being fixed and dilated), first described by Sir J.

Hutchinson (*Lond. Hosp. Repts.*, 1867, iv. 29); and the presence of a wound or bruise in the temporal region, are all indications that such a condition has occurred. These symptoms may, however, be closely imitated by those arising from subdural hæmorrhage, but here the lucid interval may be longer. In such a case the subdural hæmorrhage would, however, be large, and could only be relieved by operation, which in its initial stages would be similar to that undertaken for the previous condition.

Diagnosis is however a matter of very considerable difficulty. Sir J. Hutchinson (*loc. cit.*, p. 51) states: "It is a remarkable fact that the modern annals of surgery do not, as far as I am aware, contain any cases in which life has been saved by trephining for this state of things. I suppose the fact is, that death usually occurs too quickly or too suddenly to permit of either diagnosis or treatment." More recent statistics show, however, many cases of recovery. Thus von Bergmann gives 16 recoveries out of 99 cases. It is possible that these recoveries include many cases where the hæmorrhage was slower in onset, and thus allowed a diagnosis to be more readily arrived at. This is much more likely to be the case if the hæmorrhage is subdural and not from the middle meningeal artery. Hume (*Lancet*, September 19th, 1909) has recorded an interesting case of such a condition where an operation was carried out three months after the injury, a subdural collection of blood was removed, and the patient recovered.

Weisemann (*Deuts. Zeitschr. f. Chir.*, 1885) gives still better results of operative treatment. He has collected a series of cases which show that of 147 cases of intracranial hæmorrhage treated by the expectant plan 131 died, or about nine-tenths; while of 110 cases treated by operation, only 30 died or about one-third.

The Operation.—The patient having been prepared as above, a horseshoe-shaped flap is made in the temporal region with its base below and its centre in the position at which the trephine will be applied.

The artery crosses the anterior inferior angle of the parietal bone at a point one inch and a half behind the external angular process of the frontal bone, and one inch and three-quarters above the zygoma. These measurements apply to the adult skull. Mr. Jacobson advises that the centre of the wound made

for the trephine should be on a spot one inch and a half behind the external angular process, and one inch above the zygoma.

Krönlein recommends the following guides for the application of the trephine (*Deuts. Zeitschr. f. Chir.*, 1886, *Hefte* 3 *und* 4). Unless specially contra-indicated by some very decided localising symptoms, which point to a collection of blood pressing upon a definite centre, the trephine-holes should be determined thus: A line is drawn around the skull at the level of the upper margin of the orbit, and is throughout parallel with Reid's base line (Fig. 211). (*See also* page 2.) The trephine

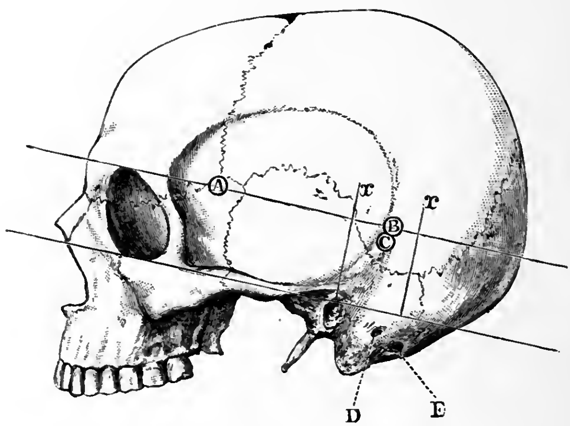

FIG. 211.—POINTS FOR TREPHINING.

A, B, Spots for trephining in middle meningeal hæmorrhage; C, Spot for trephining in abscess of the temporo-sphenoidal lobe; E, Spot for trephining in abscess of the cerebellum; D, Mastoid foramen. *See also* page 741. (*After Nancrede.*)

is first placed at a spot upon this line, which is from one inch and a quarter to one inch and a half, according to age and the size of the head, behind the external angular process of the frontal bone (Fig. 211, A).

Should the opening reveal no blood clot and no bleeding vessel, a second trephine-hole is made upon the same line, just below the parietal eminence, and at a point where a vertical line, carried up from the posterior border of the mastoid process, bisects the horizontal line already indicated (Fig. 211, B).

When any external injury or fracture of the skull exists, this should first be explored. The hæmorrhage will very probably

be found beneath the damaged bone, and one operation may suffice to elevate depressed fragments and to allow extravasated blood to escape.

The clot, when exposed, is removed by forceps, or a small scoop, aided by free irrigation.

If bleeding continue, any accessible vesesls in the dura mater should be secured by catgut ligatures, passed by means of a fine curved needle. Single bleeding points have been checked by a touch from a red-hot probe. Bleeding from the trunk of the middle meningeal artery, as it lies in its bony canal, may be arrested by plugging the canal with a little strip of gauze.

More general oozing, or such hæmorrhage as arises from inaccessible sources, may be dealt with by the application of ice to the skull, or by pressure maintained by plugging the wound with sterile gauze. In a few instances a ligature of the external or common carotid artery has been deemed necessary, and has been carried out with success.

If after opening the skull in several places no clot be found outside the dura, and the meningeal vessels appear normal, it is possible that the hæmorrhage is subdural. In such a case the dura will bulge through the opening in the bone, will not pulsate, and will be dark in colour. The dura mater should be then incised, and if clot or blood be present, this must be removed by irrigation, aided with the finger and scoop.

The operation is concluded as already described. The question of drainage is alluded to on page 30. It is possible in some instances that efficient drainage cannot be obtained through the trephine-hole already made; and in such case Dr. Nancrede advises that another bone perforation be made for the purpose at the most dependent portion of the cavity.

For the **after-treatment,** *see* page 44.

4. THE OPERATIVE TREATMENT OF CASES OF BULLET WOUND

Here we shall only consider those cases in which the bullet has pierced the cranium, and has not simply become embedded in the soft parts.

Indications for Operation.—The first question to be considered

is, should any operation involving a search for the foreign body be undertaken, or should the wound itself be simply explored, made as aseptic as possible, and drained, the brain tissue being left undisturbed in the hope that the bullet may become encapsuled and lead to no further trouble.

In cases where the patient's condition is precarious, and there is reason to believe that the bullet has passed downwards, causing severe damage to the basal ganglia, all operative interference is, of course, impossible. In other cases, where the bullet is in all probability on some part of the vertex, it has been argued that more harm may be done by carrying out a prolonged search, the exploratory probe causing further damage to the brain tissue, and the attempted removal being in many cases a failure. In spite of this, an immediate exploratory operation in all cases where the damage is not sufficient to be rapidly fatal, seems to be the correct treatment, for the following reasons :—

(1) The amount of injury to the bone, especially in regard to the inner table, cannot be determined without operation. This wound in the bone is precisely similar to a punctured fracture produced by other means, and the arguments used in favour of immediate operation in that condition would apply here also.

(2) The position of the bullet cannot be determined without operation, and it may be such that by removal of a small portion of bone it can be readily removed.

(3) The prevention of sepsis in the wound, the bone, or the meningeal space itself cannot be prevented unless the part be fully opened up, carefully cleansed, and adequately drained.

(4) The bullet, unless removed, is certain to lead to ill results in the future. Within a short space of time a cerebral abscess may form around it, whilst later other complications, such as Jacksonian epilepsy, may ensue, even many years after ; and it seems doubtful if authentic cases have been recorded where patients have remained free from all symptoms with an encapsuled bullet within the brain.

The figures of Prof. Nancrede (*Internat. Encycl. of Surg.*, vol. v.) bearing on this question are of great interest. In 106 cases the foreign body was removed; 72 recovered, and 34 died. In 210 cases the body was not removed; in these 88 recovered, and

122 died, the percentage recoveries being 69 and 42 in the two cases.

Treatment.—The primary examination and preparation of the patient is similar to that undertaken in the case of depressed fractures. The head, however, should be shaved all over, as it may be necessary to make a counter opening on any portion of the bone. The wound having been thoroughly cleansed under anæsthesia, and any foreign body or dead tissue removed, a horse-shoe-shaped flap is turned downwards, the opening in the bone is then explored, and any loose chips of bone removed. The opening is then enlarged with Hoffmann's forceps or, if necessary, with the trephine ; the opening in the dura is examined with the finger ; and if the tract in the brain tissue be large enough to permit it, this is also explored with the finger. Should it be small, a large-headed probe, such as Nélaton's, is passed along it, care being taken that only such force is used as would overcome the resistance of coagula, the possibility of making fresh passages in the brain substance being carefully considered. If any fragments of bone or the bullet itself be felt, they will be best removed with a pair of fine dressing forceps, any blood or coagula being washed away with a gentle stream of water. If the bullet be not found by these means, a counter opening may in certain conditions be made. Should there be an area of contusion, or a fracture detectable on the opposite side of the head, and the patient's condition be sufficiently good to stand further operative measures, such a course would be indicated. If there be no localising sign as above, the decision will be more difficult, and the greatest consideration will have to be paid, first to the size and weight of the missile (the heavier the bullet, the more likely is it to have pursued a direct course and to have traversed the whole of the brain substance), secondly to the general condition of the patient (if this be at all doubtful he should be returned to bed and a second operation undertaken when his condition is improved, and after the position of the bullet has been localised).

If it be decided to make such a counter opening, a flap on the opposite side of the head is turned downwards and that portion of the bone removed which would lie in a straight line with a probe placed in the tract of entry of the bullet. If blood or lacerated brain tissue be found here, a search should be made

for the bullet; if, on the other hand, the appearance of the underlying tissues be normal, this wound should be closed up.

In either case, whether the bullet be removed or not, the primary wound must be drained, and if it be removed from a secondary wound this should be drained also. In regard to drainage material, much has been said against the use of tubes; but it will probably be found best to use small spirally-cut tubes, provided with a thin gauze wick. These should not be left in for more than forty-eight hours, owing to the irritation which they may themselves cause. Should it be necessary to continue drainage for a longer period than this, they should be replaced with a thin piece of sterile or iodoform gauze.

In cases where a bullet has remained buried for some time and has then commenced to set up symptoms, or where immediate operation has failed to remove it, attempts to localise it should be made with the Röntgen rays. By means of radiographs taken in different positions, by stereoscopic views, and by an ingenious application of the method of parallax with the screen, the exact position of the body may be determined with a fair measure of accuracy. The condition of the patient having been then improved as far as possible, a further operation may be undertaken for the removal of the bullet on the same lines as above.

5. THE OPERATIVE TREATMENT OF EPILEPSY AND OTHER CEREBRAL TROUBLES OF CORTICAL ORIGIN

Indications for Operation.—As a method of treatment of ordinary epilepsy, trephining is useless. It is only in those cases in which the convulsions are of the so-called Jacksonian type that it is worth trying. These are usually the sequence of trauma, and several conditions may be found which are the direct cause of the cerebral irritation. In some there has been a history of a scalp wound only, with no evidence of fracture to be found. A scar may be seen on the scalp, pressure upon which may even cause the onset of a typical Jacksonian fit. It is possible that in such cases the trauma has been associated with superficial cortical laceration, the subsequent scarring of which has acted as a direct irritant. In others there may be depressed spicules of bone, or even a depressed area of the whole thickness of the cranium,

though such, owing to more perfect primary treatment, is becoming rarer; or an osteophytic growth may have formed at the site of a previous fracture. The irritation may in other cases be due to an old extravasation of blood beneath the bone or dura, or localised inflammatory thickenings of the meninges or the brain substance.

The most hopeful cases are those in which a group of muscles on one side of the body only are first attacked by the convulsive seizure, and in which there is evidence of past injury over the centre corresponding to the movements of such muscles. It may be that the removal of an area of thickened bone or dura, or the evacuation of a traumatic cyst, will suffice to cure, or at any rate relieve, such a case of post-traumatic epilepsy. Unfortunately, even when the localisation has been of the clearest the surgeon may find no evidence of disease at the time of operation, and by some the results of trephining are considered so disappointing as hardly to justify further trial. In the hope of improving these results, especially where no obvious lesion in bone or dura is found, Sir Victor Horsley has recommended and carried out excision of that part of the cerebral cortex which corresponds to the predominant muscular spasm ("the epileptogenic centre"). This, however, of necessity leads to subsequent paralysis of the affected part, and the question has been raised whether the condition of the patient will be thereby improved. In the greater number it probably will be, and certainly in those cases where the presence of constantly recurring fits makes the patient's life a misery to him, a permanent paralysis will seem to him preferable to his previous condition. Moreover, in some cases, especially in younger people, it has been found that the consequent paralysis may greatly decrease, and even in time completely disappear. The whole matter is one which must be fully explained to the patient and largely left to his own decision.

The Operation.—The patient having been prepared, and the affected part localised, as previously described, a trephine is placed over the affected area and a portion of bone removed. If the irritant be visible in the bone itself, this part, if not included in the trephine circle, is also removed. The hole thus made is left open, and the flap replaced in position and sutured. No

attempt should be made to fill the bone cavity. New bone will probably form here, but it is the aim of the surgeon to leave this portion of the brain as free as possible, which could not be adequately accomplished if the bone were replaced. If no cause be found in the bone or dura, the latter is opened.

After the dura has been incised, in order to localise the centre the electrodes of an induced current battery are used to the cortex. By this means spasmodic movements are obtained, and the centre is mapped out which it is desired to excise. All vessels going to this area having been carefully tied, the area is excised with a sharp knife, sufficient brain substance being removed to lay bare or even penetrate the white matter. The electrodes are again used to determine if the whole of the affected area has been excised. This procedure leads to subsequent scarring, which is very liable to cause recurrence of the original symptoms. For this reason efforts must be made to reduce the scarring to a minimum. It may be attempted by interposing a layer of gold foil, or preferably a thin agar-agar plate, between the dura and the brain substance. Great care must be taken as to asepsis, and, if possible, the dura (which has been reflected in a flap) should be sutured in place again. If hæmorrhage from the cortical wound persists it is best to provide for drainage at one corner of the flap.

The risk attending an operation so extensive as that described is considerable; and it is difficult to give a true estimate of its value as a curative measure, since it has only been practised for a few years. From observations upon more lately recorded cases, it seems to be an operation which has failed to realise sufficiently the beliefs in its efficacy. In the majority of cases the treatment should be preventive, and no excuse can be offered for those who fail to do an early operation in cases of depressed fracture where no symptoms are present. In one paper on the subject (Langenbeck's *Arch.*, 1902, vol. lxvii.) a Russian surgeon, Rasumowsky, narrates seven such cases of traumatic epilepsy operated on by himself after Horsley's method, including excision of the cortical centre. In each case an osteo-plastic flap was turned down and replaced at the end of the operation, the dura being sutured. Galvanism was used in the manner described. One patient died of late septic infection, and in two of the remaining six the con-

vulsions entirely ceased. In one some improvement followed, whilst in three the operation entirely failed.

Mr. Damer Harrison (*Brit. Med. Journ.*, February, 1907) gives a more favourable record of twenty-four cases of his own (with thirty-one operations). Six of these patients died—that is, 25 per cent.; but "not one of the deaths was attributable to the operation." Of the eighteen who recovered, in twelve a cure resulted. Dr. E. G. Mason (*Med. News*, New York, vol. i., 1896), out of seventy cases, gives only three where a cure has lasted three years.

That a few cases are benefited for long by the operation cannot be doubted. In one of Sir V. Horsley's cases trephining and excision of the scarred portion of the motor area has been followed by cessation of the fits for fourteen years. This is the longest period yet recorded.

It may be emphasised that favourable results can only be expected from operation (1) if the epilepsy is of the Jacksonian type, and has not existed for so long that the epileptic habit has become firmly established; (2) if it has followed an injury to the head; (3) if this injury has implicated the motor area of the cortex, on either side of the fissure of Rolando; and (4) if the operation be conducted under strict asepsis and the part excised includes the scar and surrounding "unstable" portion of cortex.

It is obvious that a certain degree of paralysis will follow the operation, according to the extent of the excision, but improvement may in time take place.

Sir Victor Horsley has never known a case in which the frontal region of the brain had been implicated improve after operation, nor is the prognosis much better when the sensory area—occipital and temporo-sphenoidal lobes—is concerned.

Operation in cases of congenital cysts within the cranium will only give good results if done in early life. In one case operated on by one of us (J. H.) the convulsive seizures shortly before the operation were almost continuous. Immediate relief followed the evacuation and drainage of a subdural cyst, and at the end of a few weeks the man appeared to be cured. Subsequently, however, he died from a recurrence of the convulsions.

In a very few cases where Jacksonian epilepsy has been

associated with an irritable scar, a cure has followed excision of this with liberation of any involved nerve terminals.

In cases of hystero-epilepsy no operation of any sort should be performed.

Trephining with free removal of bone has been tried in several inveterate cases of cephalalgia—*i.e.*, those which have resisted all medical treatment. The results have been much more encouraging than in traumatic epilepsy. Trephining was suggested for general paralysis, and had in the treatment of this disease a brief and inglorious career.

6. THE OPERATIVE TREATMENT OF INTRACRANIAL SUPPURATION OF TRAUMATIC ORIGIN

Suppuration within the cranium may occur from trauma when it is secondary to an acute osteo-myelitis, or it may be secondary to acute septic conditions of the middle ear. The treatment of this latter condition will be dealt with later among the complications of otitis media.

In the majority of the cases following trauma the pus is chiefly collected between the bone and the dura mater; but it may be mainly situated in the brain substance. In either case the bone may be affected, a septic thrombosis of the diploic veins, associated with necrosis of areas of bone of varying size, being often but the preliminary stages of a fatal pyæmia.

(1) **Extradural Suppuration.**—This occurs most commonly after a depressed fracture, where asepsis has not or could not be obtained. After several days' latency, signs of suppuration may occur in the wound, associated with headache or vomiting, passing on to twitchings, paralysis, and coma. Optic neuritis may be present.

The bone around the fractured area becomes necrotic, the dead portion rapidly increasing in size and being often only limited by the sutures; the veins within the diploë are thrombosed with a purulent clot. Beneath the bone may be a collection of pus, which may be limited in area, or associated with thrombosis of the cerebral sinuses and lepto-meningitis. Unless treatment be carried out in an early stage, signs of pyæmia are certain to follow.

Indications for Operation.—The treatment should in these cases be, of course, preventive. If the rule were closely followed that all cases of depressed fracture, excepting pond depressions in children, should be treated by immediate trephining, this condition would become rare.

As soon as evidences of suppuration in the wound arise, it must be opened and thoroughly cleansed. If there be indications of osteo-myelitis or intracranial suppuration, an operation should be undertaken to allow adequate drainage.

If the later signs of pressure, such as marked paralysis or coma, be present an operation holds out but small hope of success, and the same is true if there be signs of general pyæmia; but even in these cases recovery may occasionally occur if adequate drainage of the primary source of infection be provided for, and operative measures should be undertaken.

Operation.—The patient having been anæsthetised, the wound is fully opened up. Any necrotic bone is now removed, or if simply bared the outer table is chiselled away, and if there be pus or septic thrombi within the diploë the opening must be enlarged until the limits of this are reached. The centre of this area is now trephined through until the dura is reached. If there be any sinuses adjacent, they should be explored, preferably with a hollow needle. If found to be thrombosed they should be opened, as much of the septic clot as possible being removed. Any pus outside the dura is washed away, and the whole area rendered as aseptic as possible. The condition of the dura mater itself can now be investigated. If it be natural in appearance, does not bulge outwards, and pulsates regularly, nothing further need be done; if, on the other hand, there be no pulsation, with marked bulging, it must be opened, and as much purulent fluid as possible removed from the arachnoid space. Free drainage must be provided for.

(2) **Cerebral Abscess.**—Traumatic cerebral abscess is more prone to follow punctured fractures, especially those of the base, in the orbital, nasal, or temporal regions. They may be associated with a condition similar to that described above, and be followed by pyæmic symptoms. Here, again, the injury may be followed by a latent period of some days before any indication of intracranial suppuration is apparent. Headache then occurs,

sometimes limited to the area of suppuration; there is vomiting, with often a lowered temperature and slowed pulse, with mental dulness passing on to coma. In other cases localising symptoms may be present; that is to say, the symptoms of pressure dominate those due to septic absorption.

Operation.—At as early a stage as possible the wound must be opened up and the depressed portion of bone removed, either by trephine or by chisel, the opening being sufficiently enlarged to allow of exploration of the brain tissue. If there be localising signs a second opening should be made on the part indicated; while, as has been already pointed out, if the wound be through the orbital or nasal plates, an opening should be made through the frontal bone just above the supra-orbital ridge.

The portion of bone having been removed, any pus or septic material lying on the dura mater is removed, the part being made as aseptic as possible. The brain tissue is then explored. This may be done with a thin trocar and cannula, or preferably with a stout exploring needle on a syringe. The trocar and cannula are usually advocated, as the lumen can be cleared; but this difficulty can be readily overcome if a stout needle be used, either by suction or with the aid of a sterile wire. This latter method has the advantage that gentle suction can be applied.

The needle must be pushed straight in, care being taken that no lateral movements take place. Several punctures should be made in different directions. If pus be found, a pair of thin-bladed sinus forceps are inserted along the needle, this latter withdrawn, and the blades gently separated. The abscess may be simply allowed to drain or be washed out with a slow stream of saline or perchloride. Drainage must be maintained with a soft tube.

7. THE OPERATIVE TREATMENT OF CEREBRAL TUMOURS

On May 12th, 1885, a paper in every way remarkable was read before the Royal Medical and Chirurgical Society by Dr. Hughes Bennett and Mr. Godlee. In this communication an account was given of the accurate diagnosis and the successful removal of a tumour of the brain. The operation was performed on November 25th, 1884. The patient lived four weeks. The

account of the case forms an admirable exposition of scientific precision and surgical acumen.

From this case cerebral surgery as a practical measure may be said to date.

During the last five-and-twenty years much work in this department has been done by Sir Victor Horsley, Sir William Macewen, Mr. Ballance, Professor Keen, and others in this country, in the United States, and on the Continent, and a large number of operations have now been undertaken for the following varieties of tumours :—

Localised tuberculous foci.
Gliomata.
Sarcomata of the dura or brain.
Cysts.
Syphilitic tumours.

In the majority of cases the operation has been done with the intent radically to remove the whole growth ; but in a certain number, owing either to inaccessibility of the site or the size of the tumour, it has been performed solely with the idea of relieving pressure and thus leading to an abatement or relief of the symptoms.

Comments on Operation.—Before discussing the value of operative treatment in the individual varieties of tumour, it may be at once stated that the hopes raised that cerebral tumour could be cured by operation have, in the great majority of cases, failed to be realised. The operation, even if done in two stages, is a very severe one, accompanied with considerable hæmorrhage and shock. In many cases exact localisation is difficult or impossible ; in some a neoplasm may have been growing for some months in one of the silent areas of the brain. In its later stages there may be signs of pressure, or, from involvement of one of the motor areas, localising symptoms may make their appearance ; in such cases it is impossible to determine the extent of the damage, and many such have been operated upon, only to be found hopelessly beyond surgical removal. In others, such localising symptoms as are present give rise to the belief that the growth occupies a position different from its real site. In any case, localisation within the brain is a difficult matter, and one which should, in the majority of cases, be left

in the hands of the physician. A brief sketch of the symptoms arising in lesions of various areas has been given in a previous section ; but for a clear account of the difficult subject, both of diagnosis and localisation of cerebral tumours, the reader is referred to the Lettsomian Lectures delivered in February and March, 1907, by the late Dr. C. E. Beevor.

In other cases, again, although the position may be fairly readily determined, its site is such that it is beyond operative interference, or can only be dealt with by a long, tedious, and probably fatal operation.

In some cases, the tumour of the brain may be secondary to some small focus elsewhere, which has not as yet produced any symptoms directing attention to its presence ; in such the recurrence locally or in other parts is almost inevitable.

It is this inability accurately to determine the condition of the tumour before operation that causes so high a mortality and makes the present treatment so unsatisfactory, and a post-mortem examination of many cases shows a very small percentage in which operative treatment could have been carried out with hopes of a successful result. V. Bergmann ("Surgery," vol. on Head and Spine) gives 6 to 7 per cent. as the number of suitable cases, whilst Dr. Bramwell (*Trans. Med.-Chir. Soc. Edin.*, vol. xiii., 1894) gives under 4 per cent. On the other hand, the very fact that diagnosis is difficult is an indication for exploration. A condition may be found, such as a cerebral abscess or localised growth of the dura, which offers fair hopes of successful removal, and it must be remembered that a true neoplasm, unless dealt with operatively, will ultimately prove fatal, and that, even if complete removal be impossible, much temporary good may be done by removing an overlying area of bone and thus relieving the compression upon which most of the symptoms depend.

Operative treatment may, therefore, be considered justifiable with the following conditions :—

(1) Where the locality can be accurately determined and the symptoms are such as to point to the tumour being small in size.

(2) If it can be readily reached, and more especially if it be within the motor area.

(3) If its symptoms are such as would lead one to believe that it is a fibroma or localised sarcoma—the other tumours being, in the majority of cases, but poorly defined from the brain tissue, and thus not readily removable.

As regards operation in the different varieties, a tubercular focus is but rarely suitable for removal. In the majority of cases it is associated with foci elsewhere, either in the brain or other organs; but successful cases have been reported where the symptoms pointed to a chronic lesion, evidently localised, and such an authority as Sir Victor Horsley (*Brit. Med. Journ.*, 1893, p. 1365) has decided strongly in favour of operative measures where well-defined symptoms, such as severe headache, vomiting, and commencing blindness, are present.

In the great majority of the cases of gliomata and sarcomata the difficulty lies in enucleation. Gliomata, as a rule, have no capsule, the substance of the growth passing insensibly into that of the brain tissue; and even on microscopic section no limitation may be visible. In sarcomata a membrane is at times present, but in the majority it cannot be distinguished. Removal is thus made almost impossible, and attempts may be associated with severe hæmorrhage; but cases have been recorded where removal, manifestly incomplete, has been followed by a marked decrease in the symptoms, with prolongation of life.

Cysts should in all cases be removed, if possible, when their position is accessible. They may, however, be but part of a new growth, and hence removal of the cyst leads but to a temporary relief. In cases where removal is impossible, prolonged drainage may lead to its obliteration.

Syphilitic gummata have afforded a considerable proportion of the really successful removals of cerebral new growths; but as they are not true tumours and nearly always yield to iodides, operation scarcely seems justifiable. Such treatment is advocated by Dr. Bramwell (*loc. cit.*) on account of the symptoms that are left after the acute condition has subsided, but as these are generally due to remaining scar tissue, little benefit can result from removal.

Preparation of the Patient.—The head is shaved and cleansed as already described. The situation of the growth is marked out upon the scalp, and after the anæsthetic has been adminis-

tered, this surface-marking is transferred to the skull by boring small holes here and there with the finest trephine pin. Very strict antiseptic precautions must be observed throughout.

The Anæsthetic.—A hypodermic injection of morphine is administered, in suitable dose, one hour before the operation. The anæsthetic advised is chloroform, on the ground that it induces less cerebral excitement. The morphine has the effect of contracting the arterioles of the central nervous system, and hence of lessening hæmorrhage. At the same time, it allows of less chloroform being given.

Operation.—This should preferably be done in two stages. In the first, an opening of sufficient size should be made in the bone, or an osteo-plastic flap should be turned down. In the second stage, undertaken five to seven days later, the dura is opened and the condition of the brain dealt with. By this means the shock is greatly diminished, and the subdural space may in the interval be shut off, and thus blood does not escape into it. If the patient's condition be not good, the second operation may in some cases be done under local anæsthesia.

Scalp Incisions.—A single flap is raised, the outline of which is a shallow curve. It is free below, and is so planned as to avoid the main scalp arteries, and to permit of free drainage when the patient is recumbent. The pericranium is separated by the rugine over the area exposed, and is turned back, together with the other structures of the scalp. All bleeding must be arrested before the trephine is applied.

Exposure of the Brain.—This may be effected by the large trephines. An opening may be made at the two extremes of the area to be removed, and the intervening bridge of bone may then be divided by means of Hey's saw or the chisel and mallet. The dura mater during the process will be protected by a thin metal spatula. If the operation be completed in one stage the fragments of bone removed may be preserved in the manner already described, and replaced before suturing the soft parts. Under present aseptic methods this is, however, often unnecessary, large openings in the bone completely filling up after a short space of time.

A better way of exposing a large surface of dura mater consists in turning down a flap which includes scalp, pericranium,

and the subjacent bone. The flap should be more or less rectangular with its attached base downwards. At each angle a half-inch disc of bone is removed by the conical trephine. For the rapid formation of these openings Macewen's trephine may be used. This is made after the manner of a carpenter's centre-bit. The trephine itself is provided with a guard (*see* Fig. 212). The first opening being made in the usual way, the thickness of the bone is judged and the guard set for this. The other openings may be then rapidly made. This method is open to the objection that the guard can only be placed approximately owing to the varying thickness of the skull in different parts.

A flexible metal director with a broad groove is then carefully introduced from one trephine hole to another, separating the dura mater and pushing it inwards. A hooked probe is now passed in the groove of the director, and by its means Gigli's

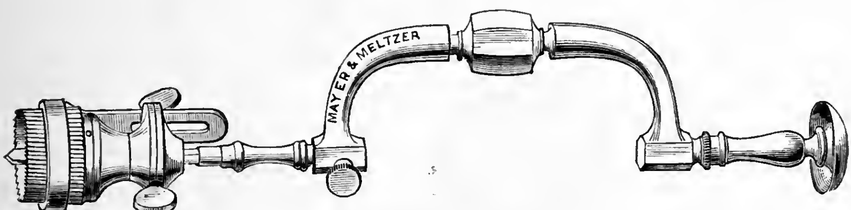

FIG. 212.—MACEWEN'S TREPHINE.

wire saw is drawn through and the bone divided from within outwards. It is well not to saw very quickly, as the narrow blade may become over-heated or break. Gigli's saw is practically a fret-saw. In using it the bone should be sawn obliquely, so that, in the portion removed, the outer table is larger than the inner, reposition by this means being more accurate. All the four angles of the bone-flap having been united by the saw-lines, it is turned downwards, with its overlying pericranium and scalp. The bone may be divided with a chisel instead of by the above method, the bone flap then corresponding in shape with that of the soft tissues (*see* Fig. 213).

If the patient now manifests any sign of shock, the flap is replaced, held in position by three or four sutures, and he is returned to bed, the second step being undertaken in six or seven days' time.

The dura mater is now divided around about four-fifths of the margin of the aperture in the bone. The incision is made about one-eighth of an inch from the bone, so as to leave room for suturing. The incision may be conveniently commenced

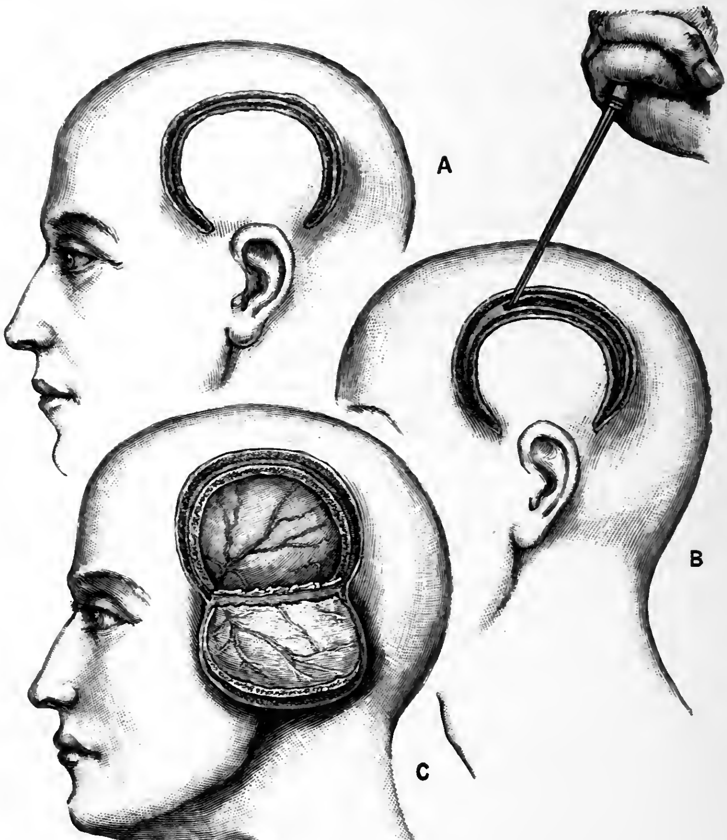

FIG. 213.—TEMPORAL RESECTION OF SKULL.
A, Incision through soft tissues down to the bone; B, Groove being cut in the bone; C, Flap of bone and soft tissues turned down *en masse*.

with the scalpel, and completed with slender blunt-pointed scissors.

All arteries lying in the line of the proposed incision must be tied, and this is most readily done by passing the ligature with a fine curved needle in a handle. The brain is now exposed, the

flap of dura mater being held aside by a suture passed through its margin.

The condition of the underlying parts is then investigated. This is best done by means of the finger-tip, exploration with a needle being untrustworthy. The consistency of the tumour may so closely resemble that of the brain substance that it may be impossible to determine its presence or size until the brain has been incised.

If by these means it is found that the tumour cannot be removed, the dura may be replaced, but not sutured, no bone being returned, the soft parts alone being sutured into position. By this means the symptoms of compression may be greatly relieved.

Removal of the Tumour.—Incisions into the brain must be clean cut, be vertical to the surface, and be directed into the corona radiata when necessary, so as to avoid damage to fibres coming from other portions of the cortex. The growth may be enucleated by means of Horsley's flexible knife, or by a broad hernia director or an elevator. In all cases, adherent or altered dura mater must be excised. If the growth be a large and ill-defined glioma, complete removal of which is impossible, it is best to remove as much as can be safely taken away, even this being in some cases followed by relief lasting for several years.

When a portion of brain has been cut away, the underlying cerebral tissue soon bulges up, and obliterates the hollow left by the loss of substance.

Hæmorrhage from the brain tissue is seldom troublesome. The arterioles for the most part run perpendicularly to the cerebral surface. Most of the bleeding is soon checked by sponge pressure, by ice, or by the use of sterilised adrenalin solution. The actual cautery should never be employed to arrest bleeding from the brain. Extensive divisions of surface blood-vessels may be avoided by lifting them out of the sulci between the convolutions, and replacing the pia mater after the tumour has been removed.

The treatment of bleeding from large meningeal arteries and also from the venous sinuses has been already alluded to (page 27).

Closure of the Wound.—The flap of dura mater is brought into place, and is secured to the unwounded part of the

membrane by a few fine catgut sutures; space, however, must be left for drainage.

If a large flap of bone has been turned down with the flap of scalp (Fig. 213), it should be replaced. In some cases, however, where the tumour has not proved capable of being removed, it is best to leave a considerable gap in the bony vault.

The scalp flap is now brought into place and secured by silkworm-gut sutures, room being allowed for drainage. The drainage-tube reaches to the surface of the wound in the brain, and is placed at the most dependent part of the wound when the patient lies supine. This tube is only retained for twenty-four hours. A voluminous aseptic dressing is then applied.

After-Treatment of Cases of Trephining.—The patient is kept absolutely at rest, and the room occupied should be perfectly quiet. The head should be a little raised. The wound is dressed upon ordinary surgical principles. In cases of fracture, or in cases of trephining for epilepsy, etc., where no lesion of the dura mater exists, draining by catgut will suffice. In cases of trephining for the removal of a brain tumour, or the evacuation of a cerebral abscess, drainage with a tube is necessary. In the former case the tube is retained for twenty-four hours only; in the latter it is retained until the abscess cavity has practically closed, and is shortened as often as required. In a few instances of intracranial suppuration a second opening in the skull may be necessary to ensure perfect drainage.

If, after the removal of the drainage-tube, pain and throbbing in the wound be complained of, and if the scalp flap appear to be raised up, it may be necessary to reopen the track of the drainage-tube to allow pent-up discharges to escape.

Sutures may be removed at any time after the fifth or sixth day, or be retained as long as appears needful. If a hernia cerebri form, it can best be treated by means of a pad of gauze and wool, kept constantly wet with absolute alcohol. The surface of the protrusion hardens, and forms a species of scab or cuticle, which in time becomes quite tough, and affords an efficient covering to the exposed brain.

The patient will need to remain in bed until the wound is

soundly healed. From two to three weeks will represent an average time..

The diet is such as is advised after any grave operation.

8. OPERATIONS ON THE SKULL FOR MICROCEPHALUS AND HYDROCEPHALUS

Operation for Microcephalus.—In the first edition of this work an account was given of the operation of "craniectomy" done with a view of allowing the microcephalic brain to expand. The results have been, however, so unsatisfactory that few, if any, surgeons now regard it as a justifiable procedure, and there is no doubt it was founded on an erroneous view of the pathology of the disease. In other words, the skull in these microcephalic children is small because the brain is badly developed, and not *vice versâ*.

Operations for Hydrocephalus.—In certain cases attempts have been made to cure this condition by removing the fluid from the lateral ventricles. Such operations may aim at either a *temporary* or a *permanent* drainage.

The *temporary* method is undertaken for a condition of rapid onset, usually due to some form of meningitis. It may be done either by simple puncture or trephining.

In the first case the scalp is shaved and cleansed; a small incision is made through the skin at one lateral angle of the anterior fontanelle; a small trocar and cannula, or Southey's tube, is then passed through the incision, traversing the thinned cerebral substance to enter the distended lateral ventricle. When sufficient fluid has been drawn off, the tube is withdrawn, the small opening in the skin is closed with one stitch, and a dressing applied.

In the second case a flap is turned downwards on one side, and a portion of bone removed with the trephine, the pin of this being placed $1\frac{1}{4}$ in. behind and above the auditory meatus (Keen), and a tube passed into the ventricle. When sufficient fluid has been withdrawn the wound may be closed, or drainage kept up for a few days by passing a small tube into the ventricle.

The *permanent* method has been undertaken for chronic

hydrocephalus or congenital cases, in the hope that removal of the fluid will allow a consequent growth of the brain tissue. The operation aims at the formation of a permanent communication between the lateral ventricle and the subdural space, fluid being readily absorbed from this latter position. The following is that advocated by Sir W. Watson Cheyne ("Manual of Surgical Treatment," Part V, 1906).

A flap being turned downwards, an opening is made in the upper anterior angle of the parietal bone. The dura mater is incised, and a wisp of catgut enclosed in a rectangular decalcified bone tube is thrust into the lateral ventricle, in such a way that one arm passes directly into the ventricle, whilst the other passes into the subdural space parallel to the brain surface. The dura and overlying soft parts are then sutured. Krause (*Berl. klin. Woch.*, June 20th, 1908, page 1165) advocates draining the ventricles into the subcutaneous tissues rather than into the subdural space. The skull having been perforated over the anterior horn, a fine silver-gilt cannula is passed into the ventricle. The projecting portion of the cannula is cut and bent over to form two flanges outside the bone and beneath the flap. The tissues of the scalp are now sutured back into position.

Comments on the Operations.—The first methods are only temporary, but often cause marked relief. As, however, the underlying condition is, in the majority of cases, a progressive one, the hydrocephalus, with its associated pressure symptoms, soon returns, the patient ultimately dying with coma, convulsions, etc. It is possible, however, that cases may occur in which the cause is only transient, and by this means the patient might be kept alive until it had ceased to act.

As regards the permanent method, the hydrocephalus is, as a rule, readily cured by its means, and a diminution in the size of the skull, with over-riding of the bones, shows that rapid absorption has taken place. In a large number of the cases, however, death has occurred in a few weeks' time with symptoms of slow but progressive meningitis; and even if this has not happened there has been no attempt on the part of the brain at re-growth or expansion; and as operative measures have not usually been undertaken until the brain has undergone considerable secondary atrophy, the operation has not so far been followed with

any marked success. Should any such cases be dealt with in the future at an earlier age, it is possible that better results may follow.

9. OPERATIONS ON THE FRONTAL SINUSES

The frontal sinuses are opened up with the trephine in certain cases of disease of the lining membrane of those cavities, and especially in such affections as are associated with occlusion of the infundibulum.

Before opening up the sinus in such cases, an attempt should be made to drain and cleanse it by opening up the infundibulum from the nose. As this is a matter of considerable difficulty, it is best left to one having special experience in nasal surgery.

In cases of necrosis, accompanied by the retention of fœtid pus, this operation has been carried out with success.

The frontal sinus is an irregular cavity varying greatly in size in different adult subjects. The two sinuses may rarely communicate, across the median line, the septum being incomplete above. Operation for empyema of the sinus may therefore be necessary on both sides, but as a rule only one is affected. These cavities are absent in the infant, are very small in children, and hardly have an existence, from a surgical standpoint, until after puberty. Hence operations on them will be confined to adult patients, and they should not be lightly undertaken, for they are by no means free from risk. Fatal meningitis and osteo-myelitis have followed in several cases the operation of trephining the

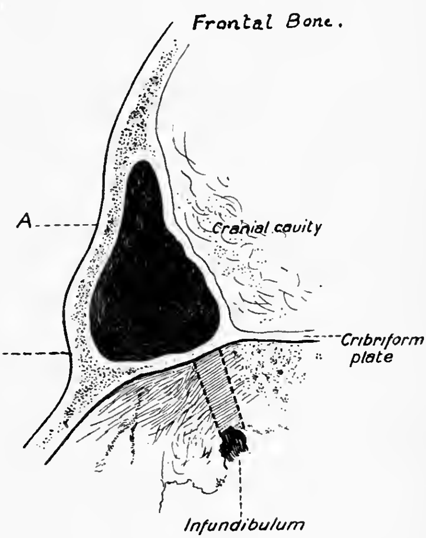

FIG. 214.—VERTICAL SECTION OF RIGHT FRONTAL SINUS.

The piece of bone between the dotted lines A and B would be removed in a radical operation; B marks the nasal notch and floor of the sinus. The thinness of the bone at the back of the sinus should be noted.

frontal sinus.* The danger of abscess in the brain or of septic meningitis resulting from frontal sinusitis, quite apart from operation, is, however, well known. It is difficult to provide proper drainage for the whole cavity owing to its extent and irregular shape, to the frequent existence of spurs or septa of bone which project into it, and to the growth of polypi or masses of granulation tissue in cases of long-standing suppuration. The aperture made in trephining the frontal sinus should therefore be placed near the floor of the sinus, and must provide free access, so that any necrosed bone or polypi can be removed and the whole cavity thoroughly cleansed. As Fig. 214 shows, the floor of the sinus practically corresponds with the nasal notch. The main cavity of the sinus is opposite to and helps to produce the superciliary eminence, and the cavity is prolonged to a variable degree in three directions.

Its upward extension rises for an inch or more between the layers of the frontal bone, the outward one arches above the orbit in some cases nearly to the external angular process, the third extends backwards below the frontal lobe in the floor of the anterior fossa for a variable distance.

In operating, it should be remembered that the front wall of the sinus is usually much thicker than that bounding any other part, and that a Volkmann's scoop or other instrument may penetrate the cranium or the orbit with ease.

The main cavity of the sinus is commonly 10 to 20 millimetres in diameter, and communicates by a channel directed downwards and backwards with the middle fossa of the nose. When the sinus has been opened, this channel (the infundibulum) should be sought for towards the posterior part of the floor, and on a plane slightly internal to the inner wall of the orbit. The normal backward slope of the channel should not be forgotten in passing probes or a drainage-tube. (*See* Fig. 214.)

Special Instruments required.—Trephines (an instrument two centimetres in diameter is perhaps the best); small Hoffmann's bone-cutting forceps, lachrymal and flexible probes, curettes, and irrigator.

The Operation.—The scar left should be as inconspicuous

* For report of two such cases, see *Brit. Med. Journ.*, September, 1892, and of two others in the same periodical, January 28th, 1905.

as possible. The incision should follow the natural fold to the corrugator supercilii, and then bend outwards immediately below the eyebrow, being thus L-shaped. The vertical limb of the incision is the shorter of the two, and may sometimes be dispensed with, as the soft tissues are readily displaced upwards. In the rare cases of suppuration in both frontal sinuses the incision should be like an inverted T, the vertical limb being median. The skin is easily retracted, and a long incision is therefore unnecessary. In dividing and reflecting the soft parts from the bone, care should be taken not to damage the supra-orbital nerve or to encroach upon the orbit. The position of the pulley for the superior oblique muscle should be borne in mind. Bleeding will be free from the frontal vessels, and must be stopped before the bone is dealt with. The anterior wall of the sinus being exposed, the pin of the trephine is inserted over the superciliary eminence, about half an inch above and to the inner side of the corresponding orbital angle. The pressure made on the trephine should be of the lightest. The opening can be enlarged as far as necessary with the cutting forceps or chisel.

After the pus has been let out and the cavity irrigated, it should be explored with the probe and finger. Polypoid growths should be cut or scraped away, any necrosed bone cautiously removed, if possible, and the various prolongations of the sinus cleansed by irrigation and use of small pieces of sponge on holders.

Chronic suppuration is rarely confined to the frontal sinus alone, the anterior ethmoidal cells and the maxillary antrum often participating. Thus it may be necessary for the surgeon to open into the first of these from the frontal sinus or to drain the antrum by the alveolar route.

If the antero-posterior diameter of the diseased frontal sinus be under half an inch or so, some surgeons remove the anterior bony wall entirely, so as to cause ultimate obliteration of the cavity. If the diameter be much more than 12 millimetres this course is hardly advisable, and the cavity must be encouraged slowly to granulate up, or Killian's operation, as described on the following page, performed.

A strong antiseptic (e.g. 1 in 20 carbolic acid in alcohol) may be used to swab the cavity out if the pus be very offensive. But all the manipulations should be conducted with gentleness

and the patient's eyes guarded from discharge or antiseptic solution by means of pads kept over the closed lids. It is rarely desirable to scrape all the lining membrane away, as the healing will be thereby protracted. The infundibulum is sought for, and, if necessary, dilated with probes. If it cannot be found, part of the inner wall of the sinus should be removed, so as to make a free opening into the nose, which will at least admit the tip of the little finger. This may be assisted by passing a finger up from the nose.

With this may be associated removal of the whole of the anterior and inferior walls, but a bridge of bone corresponding to the supra-orbital ridge should always be left (Killian's operation). By these means the cavity is ultimately obliterated, all discharges in the early stages escaping through the nose.

A thick rubber tube is now inserted, so that one end lies in the nose, the other projecting externally, with a silk loop attached so that the tube may be changed during subsequent syringing. In about a week's time it is replaced by a silver tube shaped like a tracheotomy tube; later this is removed entirely. The outer wound usually readily closes, whilst the inner to the nose remains permanent. If this method be not adopted, but a tube simply passed from the inner wound down the nose, the outer wound being closed, it will be found that the tube cannot be changed, and hence has to be removed too soon, so that the inner opening may close and pus reaccumulate.

When the mucous membrane lining the sinus has been found fairly healthy and the infundibulum patent, it is tempting to sew up the wound entirely without drainage. This course is, however, not advisable if pus has been found in the sinus, only the outer part of the wound being sutured. "The more open the wound is kept the better the result" (W. Milligan). Packing with antiseptic gauze is often used instead of a drainage tube.

After-treatment and Results.—The after-treatment is always tedious, the result uncertain. Daily syringing with peroxide of hydrogen solution or other mild antiseptic followed by light packing with moist antiseptic gauze, will give the best result, if no tube be employed. The frequent implication of sinuses other than the frontal should be borne in mind. The patient should guard against exposure to catarrh. W. Milligan (*Brit. Med.*

Journ., January, 1905) thus records the results in forty cases operated on by him :—

Successful (i.e., suppuration entirely ceased) . . .	28 cases, or 70 per cent.
Partially successful (discharge persisted, though less in amount)	4 ,, ,, 10 ,, ,,
Unsuccessful	6 ,, ,, 15 ,, ,,
Deaths (from meningitis or cerebral abscess) . . .	2 ,, ,, 5 ,, ,,

10. OPERATIONS ON THE MAXILLARY ANTRUM

In this section will only be considered those operations which deal with the treatment of inflammatory conditions of the antrum. New growths of this area necessitate removal of the superior maxillary bone, and will be dealt with in that section.

The maxillary antrum is the largest of the accessory sinuses of the nose, but its cavity varies largely in size. It is situated within the superior maxillary bone, and is roughly pyramidal in shape. Its inner wall forms the outer wall of the nasal cavity. The bone here is thin, except below where a thick angle is formed at its junction with the inferior wall. Across the middle of this wall runs the inferior turbinate bone, so that it is in relation below with the inferior, and above with the middle meatus of the nose. Above and behind in the middle meatus the antrum opens into the hiatus semilunaris, behind the openings of the middle ethmoidal cells, and the infundibulum. This arrangement explains the frequency with which suppuration within the antrum follows infection in the frontal sinus or ethmoid cells; and the fact that the opening is high up on the inner wall explains why in most cases artificial drainage is necessary after infection has taken place.

The floor is formed by part of the palate and the alveolus. When the antrum is large the roots of the teeth, especially the first molar, may project into the cavity, being only separated by a thin membrane. For this reason suppuration may take place from oral sepsis as well as from the nasal cavity. The outer wall is formed by the canine fossa, and the upper by the orbital

plate. Either of these may be absorbed when pus is under tension within the antrum.

Operations will include more or less temporary drainage for the relief of acute inflammatory conditions, and those which aim at procuring a large permanent opening situated low down, in cases where the condition is more chronic.

Operations for Temporary Drainage.—These are undertaken in acute conditions where inflammatory swelling of the mucous membrane has caused obstruction to the opening with retention of pus, or as a preliminary measure in the more chronic cases. The drainage may be procured through either the nose or the alveolus.

Drainage through the Nose.—The nose is plugged with a pledget of wool soaked in cocain 5 per cent. and suprarenal extract. A fine trocar and cannula is then passed into the nose and made to rest on the outer wall of the inferior meatus, about half an inch behind the anterior end of the inferior turbinate. It is thrust strongly outwards, backwards, and a little upwards, so as to perforate the bone at its thinnest part. On withdrawing the trocar the cavity can be drained and washed out through the cannula. This method is indicated where the teeth on the affected side are all present and healthy, and the infection is acute and evidently of nasal origin. It has the advantage that the opening is made into the nose, no teeth need be drawn, and no communication is made with the mouth. The disadvantage is that the opening closes almost as soon as the cannula is removed, and hence the condition is liable to recur.

Drainage through the Alveolus.—Here the patient is best anæsthetised with gas or ethyl-chloride. Carious teeth on the upper alveolus on the affected side are removed. If the first molar be now absent the opening is made through its socket, as the bone is here thinnest ; if not, the sockets of the second molar or bicuspid can be utilised. A small drill is pushed up through the socket until it enters the antrum. The cavity may now be washed out with a syringe, and the patency or otherwise of the normal opening demonstrated. When all pus has been removed, a small tube of silver or coiled silver wire with a cap is inserted. Irrigation may be carried out through this twice daily

by means of a small syringe, the opening being thus maintained for some days.

This method has the advantage that the opening may be maintained for several days, which in many cases is sufficient to ensure a cure. The patient is able to carry out the irrigation himself. It has the disadvantage that an opening is made into the mouth, and thus particles of food or septic material may reach the cavity. It is indicated where the teeth are carious and the infection evidently of oral origin.

Operations for Permanent Drainage.—In many cases it will be found that the above methods are insufficient, that though by their use relief may have been afforded, as soon as the opening is allowed to close the symptoms return. The lining membrane may have undergone mucoid or polypoid degeneration, or there may be areas of bare and necrotic bone, or, as mentioned above, the chronic inflammatory change may have led to absorption of the walls and distension of the cavity. In these cases a cure in the true sense of the word is impossible; the walls, being rigid, will not collapse, and hence the cavity cannot be obliterated. The membrane being in part destroyed, the normal condition cannot be regained. It is necessary, therefore, to undertake a more radical operation whereby permanent drainage may be established. The opening should be made through the nose, for if one be made into the mouth large enough to remain spontaneously open, food or septic material is certain to enter the cavity.

A general anæsthetic is usually necessary. The nasal cavity on the affected side is plugged with gauze soaked in a solution of cocain and adrenalin. The anterior third of the inferior turbinate is now removed with Grünwald's forceps and a wire snare. An electric burr is then made to perforate the outer wall of the nose. A small burr is pressed against the wall in the same direction as is advised in simple puncture; the current is now turned on, and the wall rapidly perforated. By the use of larger burrs and forceps, the opening is extended until it is about half an inch or more in diameter. The cavity may be immediately washed out. The nose is lightly plugged with gauze for the next twenty-four hours.

If it be found that owing to the size and rigidity of the septum,

the burr cannot be applied in the desired position, the operation may be performed as follows. The mucous membrane over the canine fossa is reflected upwards from the mouth, the outer wall of the antrum is chiselled away, and the cavity cleaned out. A large opening is now made through the inner wall, by means of the burr or of the chisel, and a portion of the inferior turbinate will usually have to be removed. The soft parts of the face are now allowed to fall over the opening in the outer wall, the wound soon healing.

Of the two operations the first is the simpler, and leaves an opening which is readily maintained, and it should be the operation of choice. It cannot, however, in all cases be performed, and it has the disadvantage that the cavity cannot be scraped out.

CHAPTER II

OPERATIONS ON THE MIDDLE EAR, THE MASTOID ANTRUM, AND ADJOINING STRUCTURES

I. THE MIDDLE EAR

THE complications which may attend suppuration in the middle ear and demand surgical interference are many, and the form of the operation will therefore vary much in different cases. In one case suppuration extends back in the cellular tissue over the mastoid process, in another under the periosteum of that bone; in some the mastoid antrum is full of pus which requires evacuation. In chronic cases of middle-ear suppuration a radical operation involving removal of all the tympanic contents and the posterior and upper wall of the meatus has come extensively into practice. Extension backwards of the mischief, from the tympanum or mastoid antrum to the lateral sinus, may require ligature of the jugular vein and evacuation of the sinus itself. Necrosis of parts of the petrous bone may be due to median otitis, and the removal of the sequestrum may form a special step in the operation. Exploration for cerebral abscess and meningitis may be required, and not infrequently the surgeon has gone on to this during an operation intended to be merely an opening of the mastoid antrum.

Anatomical Points.—The length, the downward curve, and the relations of the external meatus to the tympanum are shown in Fig. 215, which is drawn exactly twice the size of nature. It will be seen from it that the tympanic cavity projects upwards (as the so-called attic) considerably above the upper margin of the membrana tympani. The roof of the attic separating it from the dura mater in the middle fossa is often extremely thin and sometimes deficient, and by this route septic inflammation often spreads to the meninges or the temporo-sphenoidal lobe. At the back of the attic is the opening into the mastoid antrum

which will be further noticed. In many skulls this antrum, like the tympanic cavity, is only separated by a thin layer of bone from the middle fossa. The tegmen tympani and tegmen antri are separated by the projection caused by the superior semicircular canal.

The mastoid antrum and the attic are true extensions of the tympanic cavity, thus differing entirely from the cells in the

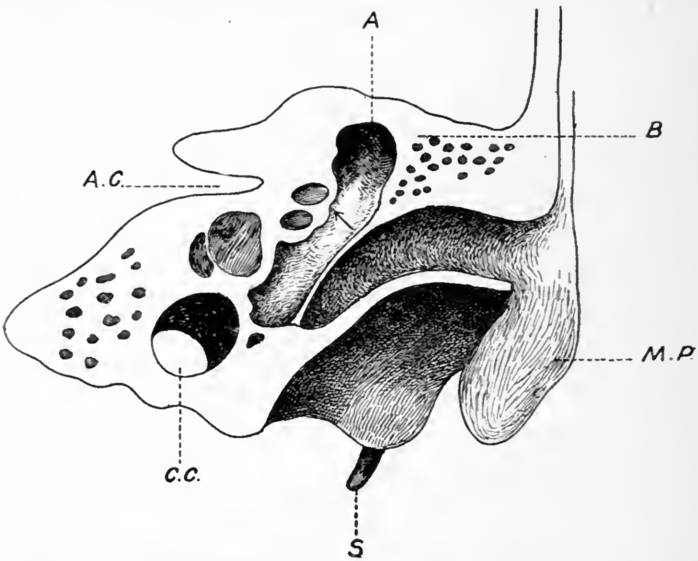

FIG. 215.—SECTION OF TEMPORAL BONE TO ILLUSTRATE THE RELATIONS OF THE TYMPANUM, ETC. (*From specimen in the London Hospital Museum.*)

The section passes downwards and forwards; the posterior half is shown. M.P, Mastoid process; A.C, Canal for auditory and facial nerves; C.C, Carotid canal; A, Attic of tympanum leading into mastoid antrum posteriorly; S, Styloid process. The dotted line from B indicates the line of section required to move the upper wall of the meatus and the air-cells, which are often invaded by suppuration. The arrow inside the membrana tympani points to the canal of the facial nerve and the horizontal semicircular canal (both seen in section). Above the carotid canal is the cochlea.

mastoid process; and there are one or two smaller prolongations which require notice, viz. that forwards and inwards, which is continuous with the Eustachian tube, and a small one under the bony canal for the facial nerve (aqueductus Fallopii). These recesses are of practical importance to the surgeon when performing the radical operation, in which no recess that contains any focus of suppuration must be overlooked.

Landmarks for the Operation.—It is not merely the depth of bone which has to be traversed that makes the operation a difficult one (occasionally the most experienced surgeon will fail to open the antrum), but the greatest care has to be taken not to injure the lateral sinus or to open into the cranial cavity. Certain landmarks should be borne in mind :—

1. The floor of the middle fossa corresponds externally to a ridge passing back from the zygoma—its posterior root—towards the asterion or meeting of the parietal, occipital, and temporal bones. This ridge or supramastoid crest (*see* C, Fig. 216) can always be felt, as also a slight depression at its hinder end where the parietal bone fits in.

2. The lateral sinus grooves the mastoid process for one-third to one-half of its width, more deeply and extensively as a rule on the right side of the body than the left. Running down obliquely from the depression mentioned above to the anterior border of the mastoid process is a strongly-marked ridge produced by the insertion of the sterno-mastoid muscle. This ridge corresponds, as a rule, fairly closely with the anterior border of the lateral sinus.

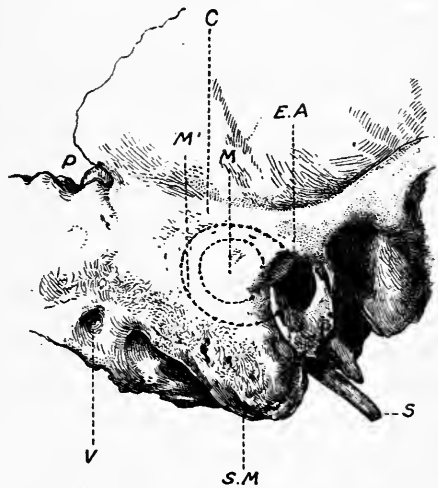

FIG. 216.—EXTERNAL SURFACE OF PETROUS BONE.

E.A, External auditory meatus; S, Styloid process; S.M, Rough surface of attachment of sterno-mastoid muscle; C, Supramastoid crest of bone continued back to P, the postero-inferior angle of parietal bone; V, Mastoid foramen giving exit to a vein; M, dotted circle indicating area cut through in trephining the mastoid antrum; M′, area of bone removed in the complete mastoid or radical operation.

As shown in Fig. 216, the operator may safely work in a triangle bounded above and behind by the two ridges described, and anteriorly by the wall of the external meatus. This triangle is nearly equilateral, each side measuring 2.5 cm.=1 inch. The gouge, etc., should be made to traverse the bone inwards and slightly forwards, parallel to the meatus itself. In young

children especially, the cranial cavity is entered with ease, and this accident may have fatal results. It is most undesirable when opening a mastoid antrum full of pus to wound the lateral sinus, as the operation cannot be properly completed, and septic thrombosis is almost certain to follow.

2. OPERATIONS ON THE MASTOID ANTRUM

This operation is called for in those cases of suppurative disease of the middle ear in which the pus has spread to the mastoid process, and, being retained, is producing more or less serious symptoms.

The operation does not consist merely in opening the nearest cells of the mastoid process, or in driving a boring instrument vaguely into that bone, but is represented by a definite and precise opening of the space known as the antrum of the mastoid. Into this central cavity the mastoid cells open, and it is, moreover, in direct communication with the cavity of the tympanum.

The bone can only be efficiently drained when this particular cell-space is opened up.

The operation is therefore not so much a "trephining of the mastoid cells" as an opening into the mastoid antrum.

Anatomical Points.—In the infant the mastoid as a distinct process has no existence; but in the mastoid segment of the petrous bone is a single air-cell, the mastoid antrum, which communicates by a large opening with the posterior and upper part of the tympanum. Its outer wall is very thin, and thus it happens that in infants pus in the antrum can very readily reach the surface, or be still more readily evacuated by operation. A small incision, extending some two lines into the bone, is all that is necessary. Across the roof of the antrum at this period runs the petro-squamous suture. About the second year the mastoid process becomes visible. As the bone increases, its growth mainly involves its external parts, so that as years pass on the antrum becomes more and more deeply placed. In a child aged nine this cell is about 1 cm. from the surface. At this period no other air-cells exist, but at puberty an extensive series of such cells develops.

In the adult the mastoid cells extend upwards to within half

an inch of the tempora-parietal suture. Anteriorly they extend forwards over the external meatus. Posteriorly they cease abruptly at the masto-occipital suture, although in rare cases they are continued beyond that suture into the occipital bone.

About the centre of the mastoid spaces is the antrum. It is about the size of a pea. Its roof is only separated from the cranial cavity by a layer of bone about 1 mm. in thickness. The distance of the posterior end of the antrum from the lateral sinus is from 3 to 6 mm., while its outer wall is from half to three-fourths of an inch from the external surface of the mastoid process.

The antrum opens into the tympanic attic (*see* Fig. 215) by a canal (the aditus) which lies behind the highest part of the auditory meatus, and the cavity of the antrum is rather nearer the surface than that of the attic. As Ballance points out, a line passing through the mastoid antrum, its aditus, or opening into the attic and the tympanum forms an angle of about 45 degrees with the antero-posterior plane of the skull.

In tracing the zygoma backwards, we find its upper border continued as a slightly curved ridge to the posterior inferior angle of the parietal bone. The latter can be usually felt as a depression through the scalp. The ridge (shown in Fig. 216) is an important landmark, as it corresponds inside the skull with the floor of the middle fossa, and limits, therefore, the surgeon's interference with the bone in an upward direction. In other words the gouge, if applied over or above this supramastoid ridge, will penetrate into the cranial cavity—an accident especially dangerous when operating on a child's mastoid process.

In Fig. 216 the dotted line M′ indicates the area of bone which it is, as a rule, advisable to chisel away in order freely to open the mastoid antrum in acute cases. The surgeon must work parallel to and close behind the upper part of the meatus just below the supramastoid ridge.

Operations upon the mastoid may be undertaken to provide temporary drainage, in conditions where there is reason to believe that the middle ear is healthy, and no marked destruction of the mastoid structures has occurred; or if the condition be more chronic a radical cure which aims at replacing the aditus by a wide opening is performed. This, however, involves

destruction of the middle ear and membrana tympani, with consequent impairment of hearing.

Simple Drainage of the Mastoid Antrum (Schwartze's Operation).—This operation is indicated in cases of acute mastoiditis, where, in spite of free drainage through the membrane, symptoms such as pain, tenderness, and pyrexia persist, and there is an obvious abscess over the mastoid; where, with otorrhœa lasting some weeks, there is bulging down of the posterior meatal wall; lastly, in cases of chronic otorrhœa, where the hearing is good and there is thus evidence that the middle ear is only slightly affected.

Instruments Required.—The best instrument for opening the antrum is a sharp steel gouge, with a handle ending in a broad round knob (Fig. 217). Two gouges, one about 5mm. wide in cutting edge, the other about 10 mm.; a metal mallet;

FIG. 217.—MASTOID GOUGE. (*Horsley's pattern.*)

fine flexible probe; curettes; Volkmann's scoops; a syringe; and Stacke's protector should be at hand, besides the usual cutting and hæmostatic instruments.

Of the many special instruments employed or advised for this operation, few have much claim to serious consideration.

Drills of any kind are to be avoided as dangerous. The surgeon has little control over their movements; they are apt to cut deeper than was intended, and are readily carried beyond their mark.

Trephines are clumsy and needlessly destructive. In children the orthodox "mastoid trephine" would cut away the greater part of the mastoid bone. They are not under very complete control, and there is no indication conveyed to the hand of the moment when the antrum is reached.

Steps of the Operation.—The meatus is syringed out and cleansed as far as possible, the external ear and skin over the mastoid process disinfected. The adjacent scalp should have been shaved and the head enveloped in a sterilised towel over a waterproof cap. The auricle being held forward by an assistant,

the surgeon makes a slightly curved incision downwards from the supramastoid ridge towards the apex of the mastoid process, parallel to the posterior wall of the meatus. A small transverse incision is usually required near the upper end of the main one. The knife goes right down to the bone, with due care not to penetrate it in the case of a child's thin mastoid process. Even if pus be found superficially to the bone, the mastoid should, unless there be clear indications that it is due to suppuration in a post-auricular gland, be opened up; especially if the patient be a child, for in the young pus from the mastoid may readily reach the surface either by involvement of the bone or by escape through the squamo-mastoid suture. With a rugine the soft parts are peeled backwards and forwards until an area corresponding to the dotted line M in Fig. 216 is exposed. The bone enclosed by this line is then gouged away bit by bit.

The instrument is directed forwards and inwards parallel with the long axis of the meatus. It is convenient to introduce a thick probe into the meatus as a guide, and to keep the gouge exactly parallel with it.

If the instrument be directed inwards at right angles to the surface of the skull at the point indicated, the antrum will certainly be missed, and the lateral sinus almost as certainly opened. The direction followed by the gouge is therefore of the utmost importance.

In the adult the antrum will be reached at a depth not exceeding three-fifths of an inch. The loss of resistance and the escape of pus indicate when the cavity is opened.

The opening is enlarged to the desired extent by means of the sharp gouge. If any necrosis be present, the gouge will need to be liberally employed. It is well to remove as much superficial bone as possible, so that the cavity of the mastoid is converted into a funnel-shaped opening. The posterior wall of the middle and external ear must, however, not be injured, the aim of this operation being to secure free external drainage of the antrum, while the middle ear is left untouched. Later on, when the external wound is healed, drainage of the antrum will have to take place through the aditus, and the patency of this opening may therefore be demonstrated with the bent probe.

The tunnel in the bone having been well syringed out, a

suitable drainage-tube is inserted, and the parts are well dusted with iodoform.

Boracic fomentations form the most suitable dressing. Gentle syringing with weak antiseptic lotions should be employed daily, followed by gauze dressings. When all purulent discharge has ceased, the opening may be allowed to close.

Comment on the Operation.—In some cases, particularly those in which there is no otorrhœa but marked swelling of the soft parts, it is unnecessary to do more than make a free opening for the pus, and follow any sinus into the bone with a scoop or gouge. Thus a mastoid cell may be found to require clearing out whilst the true mastoid antrum is normal and should be left alone. Other cases, however, may require that much of the posterior wall of the bony meatus should be chiselled away, or part of the front wall of the lateral sinus. The greatest care, however, should be taken lest the latter vein be wounded, since the only way of stopping hæmorrhage from it is to plug, and to do this probably implies premature close of the operation and grave danger of septic thrombosis. A safe rule is to work near to the back of the meatus and parallel with it, but sooner or later it happens to every surgeon to open the sinus by accident. Another danger in operating on young children, as we have seen, is that of working into the cranial cavity in mistake for the antrum. Occasionally much difficulty is experienced in finding the antrum, which may, indeed, be obliterated by sclerosis due to old inflammation.

3. THE COMPLETE OR RADICAL MASTOID OPERATION

In certain cases of long-persisting otorrhœa with marked loss of hearing an operation is performed which involves removal of the remains of the membrana tympani, the small bones of the ear, and the posterior wall of the meatus, so as to convert the tympanum and the mastoid antrum into one cavity. This is lined either by flaps from the soft tissues of the meatus or by epithelial grafts.

Indications for Operation.—The following indications for the performance of the radical cure are given by Mr. Hunter Tod ("Diseases of the Ear," 1908).

1. *As a Prophylactic Measure.*—If the otorrhœa has continued

for over a year in spite of careful conservative treatment, in order to obviate the risk of future intracranial complications. If, however, the hearing is good, the simpler operation described above may be undertaken.

2. *Repeated recurrence of polypi and granulations*, especially in the upper posterior quadrant, in spite of conservative treatment, or of the operation of ossiculectomy having been performed.

3. *Recurrent attacks of giddiness*, a feeling of nausea or persistent headaches, which are symptoms of retention of pus.

4. *Fistulæ of the bony walls* are indications for operation in that they show obvious signs of carious bone.

5. *Cholesteatomatous Formation.*—When this has been diagnosed, even if there are no immediate symptoms, operation should be undertaken, as complications are more common with this condition.

6. *Facial Paralysis or Intracranial Suppurative Lesions.*—In either case there is clear indication that the condition has spread to involve the surrounding parts, and in either case the complete operation will have to be done, even if only as a preliminary to some intracranial operation.

7. *In Acute Mastoid Disease occurring in the course of Chronic Middle-ear Suppuration.*—The complete mastoid operation should be performed, as in these cases there is invariably bone disease about the region of the attic, aditus, and antrum. In such cases it is often difficult to determine if the condition be simply an acute one, or if there be old mischief in addition. Attention must be paid to the previous history and to the presence or absence of signs of chronic inflammation seen in the tympanic membrane.

The Operation.—The patient having been prepared and the head shaved as above, a curved incision is made down to the bone, as in Schwartze's operation. The attachments of the pinna behind are now separated from the bony wall by a periosteal elevator, and the whole pinna pulled well forward until the opening of the bony meatus is well seen. The antrum is now opened, the outer wall being removed by a gouge or chisel. The cavity having been well opened, the extent of the disease is determined and any granulations or carious bone removed. Two openings are now present—that of the bony external meatus in front, and the artificial opening into the antrum behind. They

are separated by the posterior wall of the auditory canal. The outer part of this ridge is removed with the chisel, any remains of the membrana tympani usually coming away with it. In performing this step, care should be exercised to remove the bone in small pieces.

The pinna is now pulled well forward by a suture or piece of gauze pressed through the fibrous meatus. The tympanic cavity is thus well exposed, any remaining portion of the membrane, necrotic remains of the ossicles, or granulations being curetted away. During these stages the cavity of the antrum and middle ear should be kept quite dry by swabbing with mastoid strips. A probe or Stacke's guide is now passed through the aditus, so that the extent of the remaining bridge of bone may be accurately determined. This piece of bone must now be carefully removed with the chisel. It is at this stage that danger is likely to accrue to the facial nerve, which lies beneath the external semicircular canal on the floor of the aditus. It may be best protected by leaving the bent probe lying in the aditus, while the outer wall is removed. The walls of the cavity are now smoothed down with the chisel and burr. At the end of the operation the upper level of the antrum, the attic, and the aditus should lie in a straight line, the enlargement of the aditus being mainly brought about by removing its upper wall, whereby the facial nerve is in no danger of being injured. All recesses are now curetted, the whole cavity being left as smooth as possible to expedite healing. Mr. Tod advises that the opening of the Eustachian tube be carefully curetted so that scar tissue may later obliterate its lumen and prevent reinfection.

The next step is the formation of a skin flap from the pinna, which being turned back and held in position ultimately becomes the outer wall of the antral cavity. A thin-bladed bistoury is inserted through the fibrous meatus and made to cut upwards and outwards from the upper end: it is now withdrawn and made to cut downwards and outwards from the lower end. By this means a quadrilateral flap is made of the posterior part of the pinna, which is turned backwards and fixed to the raw surface of the pinna with one or two catgut sutures; or a simple and rather more satisfactory method, as advocated by Mr. Tod, may be employed. A Y-

shaped incision is made with the open arms directed backwards; by this means three small flaps to cover the upper, lower, and posterior walls are formed. The pinna is now sewn back with silkworm-gut sutures, the common cavity of the tympanum and antrum being plugged with gauze from the meatal opening. This gauze is left in position for three to four days, the cavity then being syringed and plugged daily.

An older method, advocated by Mr. Ballance, is still preferred by many surgeons. Here the operation is done in two stages. In the first the antrum is thoroughly opened and connected with the tympanum as in the first stages described above. The wound is then sewn up without forming the posterior flap. After a period of one or two weeks the wound behind the ear is re-opened, the pinna displaced forwards, and all oozing arrested. The walls of the cavity are now carefully covered with an epithelial graft taken from the thigh or arm. If possible, one graft only should be used for the whole surface. The graft may be kept in position by applying over it a layer of gold leaf, and then packing with a narrow strip of dry iodoform gauze.

Comment on the Operation.—In the radical mastoid operation, the chances of success depend to a large degree upon the after-treatment. The cavity requires careful and accurate plugging and syringing so as to prevent any adhesions forming between the granulations on either side. At the same time, any granulation tissue must be carefully removed, so that in time the wall will become covered with epithelium spreading from the flaps. This usually occupies about three months. In many cases it may be impossible to remove every portion of necrotic bone. Even small portions of this will cause a granulating area lasting for a considerable time, which will be shown by a long-continued but slight otorrhœa. The operation of skin grafting was introduced with the idea of shortening the convalescent period, but it is doubtful if anything be gained by it. If there be the smallest area of necrotic bone, the graft will break down over it, leaving a granulating area, and in many such cases it has been found necessary to repeat the grafting five or six times. If the wall be perfectly clean and aseptic the graft would probably take; but here it is unnecessary, for if flaps be made as above described, the cavity will become covered by

epithelium almost as rapidly. The necessity of performing a second operation is also a great drawback. Not only does the patient object to undergoing it when he feels in perfect health, but by this procedure the time necessary to lie up is greatly increased—a matter of no small moment to the majority of patients.

As regards freedom from complications after the operation, there is no doubt that the danger of these is greatly decreased in the majority. In a certain proportion of cases, however, probably owing generally to the treatment being undertaken too late, intracranial complications do supervene, necessitating further treatment; and in spite of this, perhaps ending fatally. In others, again, the swelling behind the ear re-forms, there is pyrexia, and other evidence of re-formation of pus under tension. In such cases it is possible that all the mastoid cells which were affected have not been opened, or that the infection has been sufficiently virulent to infect the surrounding tissues. Such complications are more common in those cases where there is an acute attack in addition to the chronic condition. In the more chronic varieties it is probable that not more than 15 to 20 per cent. of the cases fail to be cured.

From the point of view of hearing, the improvement is but slight. During the course of the operation the middle ear is destroyed, and hence a return to the normal condition cannot be looked for. As, however, the operation is only undertaken in those cases where the middle ear is physiologically useless, the patient will not have gained a further disability. In many cases the hearing, although considerably below normal, may be markedly improved.

The dangers of the operation itself, if it is carefully performed, should be slight. They consist chiefly in damaging the facial nerve, or spreading the infection into the cranial fossæ or lateral sinus.

4. OPERATIONS FOR THE INTRACRANIAL COMPLICATIONS OF OTITIS MEDIA

These complications consist in septic thrombosis of the lateral sinus, meningitis, cerebral abscess, and cerebellar abscess. The

differential diagnosis of the conditions is at times beset with considerable difficulty, and they may indeed be associated; so that although the site of the lesions may be reached by separate openings in the skull, in the majority the operation becomes more severe and complicated, so that if a patient be presented with a condition of acute mastoiditis, with symptoms suggesting one of the above lesions, the mastoid must be first opened, and the operation then continued along the lines suggested by the symptoms. If, on the other hand, the mastoid has been already dealt with, and intracranial complications make their appearance later, the old wound must be reopened and the operation continued from this point until the causative condition be met with. This is necessary, for even if the symptoms point, for example, to a well-defined abscess in one lobe of the cerebellum, but little hope of a cure can arise until the primary septic focus situated within the mastoid has been dealt with.

(1) **Thrombosis of the Lateral Sinus.**—The indication for operation is thrombosis by extension from suppuration in the middle ear. This condition, the distinguishing feature of which is the occurrence of rigors, is best met by trephining over and opening the lateral sinus, and washing out the septic clot through an opening lower down in the jugular vein. By this means many cases have been saved from impending death from pyæmia.

Landmarks for the Operation.—The lateral sinus passes from the inner side of the occipital protuberance forwards and slightly upwards to the postero-inferior angle of the parietal bone. If the ridge on the mastoid process be followed upwards it is found to end in a depression which corresponds to the genu of the lateral sinus, from which the latter bends downwards and inwards, deeply excavating the petrous bone. The sinus leaves the base of the skull just internally to the styloid process, and in front of the transverse process of the atlas. The beginning of the jugular vein is thus inaccessible to the surgeon, being placed so deeply, and if necessary the vein should be exposed lower down below the parotid gland on a level with the thyroid cartilage or hyoid bone. As it grooves the skull, the most accessible part, and that in which thrombosis from ear disease usually occurs, is the genu and the next inch of the descending portion.

If a line be drawn backwards from the lower border of the nostril through the middle of the external auditory meatus, and the pin of the trephine be placed 1½ inches on this line behind the centre of the meatus, it will be directly over the lateral sinus. The relationship of the lateral sinus to Reid's line is shown in Fig. 218. It is quite possible in some cases by trephining very carefully to lift off the bone from the wall of the sinus without damaging the latter, but, in old subjects especially, this may prove impossible. It is useful in doubtful cases to expose the wall of the sinus, and to judge, by inspection or by aspiration with a fine needle, whether the contents are normal or not. It may be noted that the lateral sinus, as a rule, lies in a deeper groove on the right side than on the left.

Steps of the Operation.—Supposing in a case of suppuration in the middle ear repeated rigors with local symptoms have made it certain that there is thrombosis, the internal jugular vein should be exposed in the upper part of the neck by an incision over the anterior border of the sterno-mastoid muscle. Care should be taken to avoid the descendens noni and pneumogastric nerves. The vein should be isolated after its sheath has been opened for an inch of its course, and a catgut ligature is put round it, after which the vein is clamped above and divided. The lateral sinus is then exposed by means of a one-inch trephine, the pin of which is inserted at the point already mentioned. The sinus is opened after its wall has been further exposed by cutting forceps, working in the downward direction. All septic clot is then removed by means of a scoop, of small pieces of sponge, and of irrigation. If the clot has extended backwards along the horizontal portion it should be removed, and the surgeon should only be satisfied when healthy blood flows out of the upper end of the sinus, and a clear current of antiseptic solution can be syringed through the severed jugular vein from which the clamp has been removed. Hæmorrhage from the upper end will be stopped by plugging with antiseptic gauze, and a second catgut ligature should be placed on the divided vein.

As the diagnosis of lateral-sinus thrombosis is not easy, it will usually be preferable, in cases where the symptoms are at all indefinite, to enlarge the opening into the mastoid antrum backwards until the lateral sinus is laid bare. Any pus around the

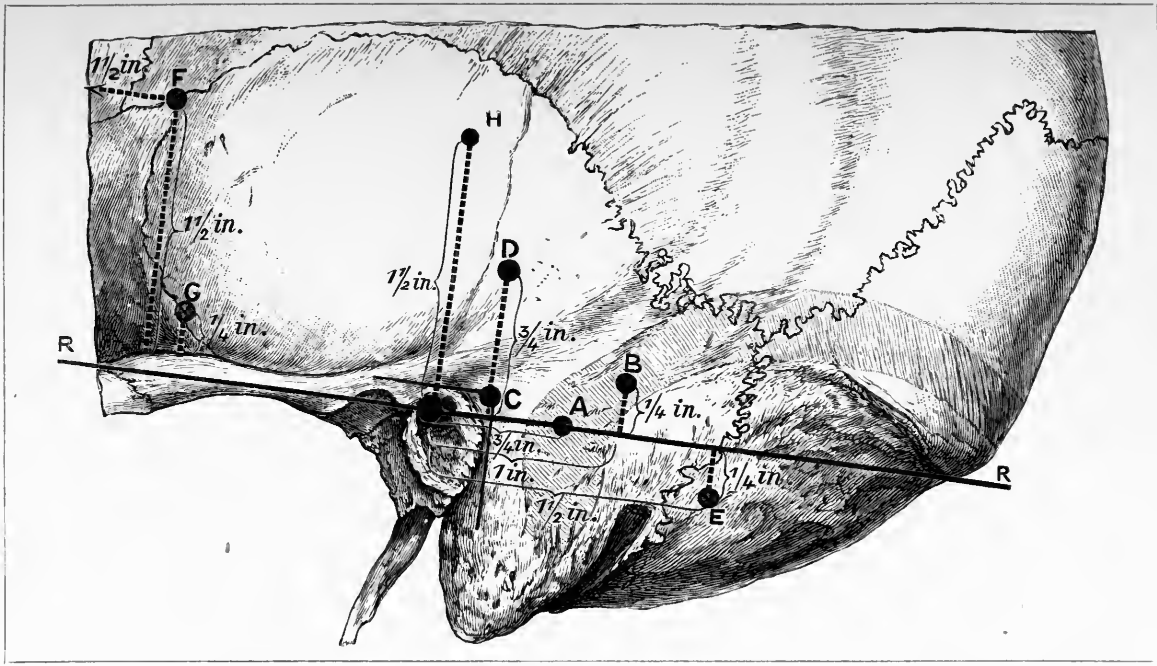

FIG. 218.—DIAGRAM OF ADULT SKULL (NATURAL SIZE), SHOWING THE VARIOUS POINTS FOR TREPHINING.

The horizontal measurements are taken along Reid's base line R R, from the centre of the external auditory meatus; the vertical measurements are taken by drawing lines at right angles to the base line. A, The sigmoid portion of the lateral sinus, a point $\frac{3}{4}$ in. along the base line from the centre of external auditory meatus; B, The transverse part of the sinus, a point 1 in. from external auditory meatus, and $\frac{1}{4}$ in. above base line; C, The mastoid antrum, the point of meeting of two lines—one drawn along the upper margin of the meatus parallel with the base line, the other along the posterior margin of the meatus at right angles to the base line; D, For cerebral abscess (temporo-sphenoidal), a line drawn $\frac{3}{4}$ in. upwards through the posterior margin of the meatus at right angles to the base line; E, For cerebellar abscess, $1\frac{1}{2}$ in. behind centre of external auditory meatus, and $\frac{1}{4}$ in. below base line; F, For anterior branch of middle meningeal artery, $1\frac{1}{2}$ in. from external angular process of frontal bone and same distance above upper margin of zygoma; G, For posterior branch of middle meningeal artery, $1\frac{3}{4}$ in. from external angular process of frontal bone, and $\frac{1}{4}$ in. above upper margin of zygoma; H, For tapping the lateral ventricle, a point $1\frac{1}{2}$ in. above centre of external auditory meatus.

sheath of this is then removed, and the condition of the interior of the sinus determined by passing a small hypodermic needle. If fluid blood be found, but little harm will have been done, as it is unlikely that infection will have been carried along the needle tract, and no bleeding will take place from the small puncture. If, on the other hand, the sinus be found to be thrombosed, this wound is covered up, the internal jugular vein isolated in the neck, and the operation continued as above.

(2) **Meningitis and Cerebral Abscess.**—These are often associated. The meningitis may be diffuse or localised, forming a subdural abscess. In these cases the infection usually occurs through the tegmen tympani, and the meningeal suppuration is either localised to or most marked in the outer part of the middle fossa beneath the temporo-sphenoidal lobe, and is therefore opened in the steps necessary to deal with a cerebral abscess. Suppuration within the cerebrum itself may be acute or chronic, and is in nearly all cases localised to the temporo-sphenoidal lobe. In the chronic variety few, if any, symptoms may be present until the abscess ruptures, leading to a diffuse meningitis. In the more acute cases the symptoms of an abscess may be masked by those due to the acute septic condition.

Operation.—The mastoid wound having been opened up and explored, the opening in the bone may be continued forward (*see* below), or a separate trephine opening may be made over the temporo-sphenoidal lobe. If the latter course be decided upon, a semilunar flap is turned upwards and the bone trephined. The pin of the trephine should be placed in a line with the posterior wall of the meatus, three-quarters of an inch above the posterior root of the zygoma (Sir W. Macewen) (Fig. 218), or in the centre of a space marked out by two lines drawn at right angles to Reid's line, each one and a half inches long ; the anterior passes through the meatus, the other one and a quarter inches behind that opening (Barker) (Fig. 211, C). The dura mater is exposed, and will usually be found to be without pulsation, and to bulge into the trephine hole. This change in the membrane is a certain sign, not necessarily of pus, but of increased intracranial tension.

The dura mater is incised with the scalpel, and is then opened with the aid of fine scissors and delicate-toothed forceps. The

division should be so made as to render the subsequent closure of the rents with sutures possible. A crucial incision will probably be the most convenient. If pus be present beneath the dura it will now escape; the cavity may be washed out, and a drainage tube inserted. If no pus be discovered, the aspirating needle is introduced; if no pus be withdrawn, the puncture may be repeated. The movement must be a direct thrust, no lateral

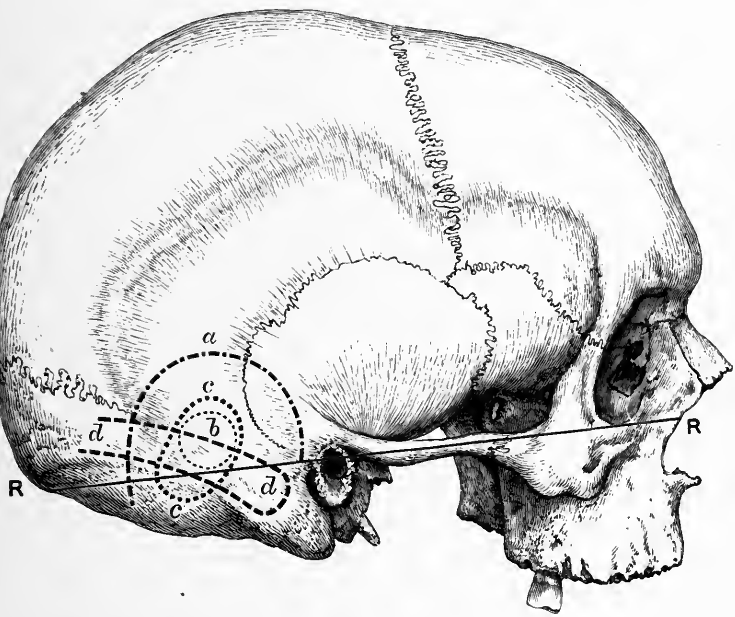

FIG. 219.—SKETCH OF AN ADULT SKULL TO REPRESENT AN OPERATION FOR TREATING THE CHIEF INTRACRANIAL COMPLICATIONS OF CHRONIC OTITIS MEDIA (reduced to one-half of natural size).

a, Line of skin incision; *b*, Pin of trephine placed $1\frac{1}{4}$ in. behind, and $\frac{1}{4}$ in. above, the centre of the external auditory meatus; *c*, Area of bone removed by bone forceps; *d*, Outline of the lateral sinus.

movement being permissible, and no attempt must be made to pass the needle from one point to another without removing and re-introducing it. When pus is discovered a pair of slender sinus forceps should be inserted along the side of the needle and the track along which the pus may escape thus enlarged.

Along the passage thus made a drainage tube of indiarubber or of silver is introduced. Rubber answers well, as it allows of being shortened as required. A double or two-way tube is very

convenient for syringing. The length of tube within the skull should measure about one inch, and must be secured in place by sutures. If the pus be very foul the cavity should be syringed out at once. The flap is now adjusted, but the sutures may be omitted at the end of the flap, so that the trephine-hole may not be entirely covered up, but that there may be every opportunity offered for the escape of pus.

Cerebellar Abscess.—This was formerly considered to be a much rarer occurrence than abscess in the temporo-sphenoidal lobe. Later statistics show, however, that they are about equally common. Korner (quoted by Jacobson) gives 62 per cent. in cerebellum, 32 per cent. in cerebrum, 10 per cent. in both. Hunter Tod (*loc. cit.*) gives different figures for children and adults. In children under 10 years, 87 per cent. were temporo-sphenoidal, 13 per cent. were cerebellar. In adults 65 per cent. were cerebral, 35 per cent. cerebellar. The diagnosis is by no means easy. The localising symptoms have been briefly indicated in the section on cerebral localisation; but, in addition to those mentioned there, lateral nystagmus and conjugate deviation of the eyes may be present. The abscess is usually in the anterior part of the lateral lobe, close to the bone disease which caused the infection (Ballance), a point of considerable importance, as it enables the abscess to be reached by a continuation backwards of the mastoid opening (*see* below).

Operation.—Here again, if desired, a separate trephine opening may be made into the skull. In this case the point of the trephine should be inserted one and a half inches behind the meatus and one quarter to one half inch below Reid's line (Fig. 218). The dura should be opened in a manner similar to that described above, and the employing needle inserted in a downward and inward direction. In some cases the needle may have to be inserted about one and a half to two inches before pus is discovered. If pus be found the opening must be enlarged and the abscess cavity dealt with as already described.

Comment on the above Operations.—As mentioned above, the differential diagnosis of these conditions is attended with considerable difficulty. For this reason a separate trephine hole with exploration of one area may result in failure to

discover the underlying cause, and not a few cases occur in which death follows the operation, and the lesion is discovered post-mortem in one of the other areas. Hence it seems desirable, unless the symptoms are very definite, that some method be used whereby a systematic search of the various areas may be carried out until the cause is discovered. In this connection Mr. H. P. Dean has pointed out that it is possible to expose the lateral sinus and the dura mater over the lower part of the temporo-sphenoidal lobe, and the cerebellum through the same trephine opening. The pin of the trephine should be placed one and a half inches behind and half an inch above the external auditory meatus.

The following will, however, be found the simplest, and at the same time the most thorough measure which can be adopted as a routine in all doubtful cases:

If the mastoid has already been dealt with, the old wound is opened up and the mastoid cavity explored. If not, this is first done. The opening in the mastoid is now prolonged backward with the chisel or with Hoffmann's forceps until the lateral sinus is laid bare. It is explored for any surrounding meningitis, and then for thrombosis in the usual way. If nothing be found, the opening in the bone is enlarged upwards until the dura mater of the temporal fossa is laid bare, and the meninges and brain in this region are explored. If still no adequate cause be discovered, the opening in the bone is continued downwards and backwards behind the lateral sinus, whereby the lateral lobe of the cerebellum may be readily investigated.

By this means all the parts liable to be infected are rapidly and in turn explored, and by the use of rapidly-cutting bone forceps, such as Hoffmann's, but little time is occupied.

If pus be found the abscess cavity is dealt with in the usual way, as described above.

CHAPTER III

OPERATIONS ON THE NERVES OF THE HEAD AND NECK

Among the operations to be described in this chapter, those for the relief of neuralgia of the fifth nerve take the first place. The cases most suitable for surgical interference are those of true spasmodic or epileptiform neuralgia. As a rule this commences in the third or inferior maxillary division, especially in the area supplied by its inferior dental branch. The attacks of pain may be at first separated by long intervals; these become shorter and the spasmodic attacks more severe, and ultimately the neuralgia spreads to other branches of the fifth nerve, including the auriculo-temporal one, and to the superior maxillary division. In the great majority of cases the neuralgia is confined to the two lower divisions—the superior and inferior maxillary ones. Even if the first or ophthalmic is involved it is but slightly so as a rule. Secondary or referred pain is frequently experienced in some branches of the superficial cervical plexus.

These considerations are important in deciding what form the operation shall take. Since at first the neuralgia may be confined for months or years to one or two branches of the trigeminal nerve, surgeons naturally were inclined to trust to peripheral nerve-stretching or excision (neurectomy); but the result of these operations, however thorough, is nearly always disappointing. After an interval of a few months the neuralgia returns and becomes worse than before. The late Prof. Billroth summed up his experience of over thirty such peripheral operations on the branches of the fifth nerve by stating that he had not once known a permanent cure result from them. It is far otherwise with the operation of excision of the Gasserian ganglion by the intracranial route, the Hartley-Krause method. Since the introduction of this the peripheral operations have passed more and more into the background. It is true that

they are less severe proceedings, but the deformity left by them has often been greater than that following the intracranial operation. In fact, if carefully performed, the latter involves little or no disfigurement.

It would, however, be incorrect to say that peripheral operations on the branches of the fifth nerve have been wholly abandoned. Now and then, the neuralgia being strictly limited to one branch, the patient may prefer the relief afforded, temporary though it may be, to the major operation.

We shall therefore first describe the operations on the Gasserian ganglion, and subsequently treat briefly the various forms of

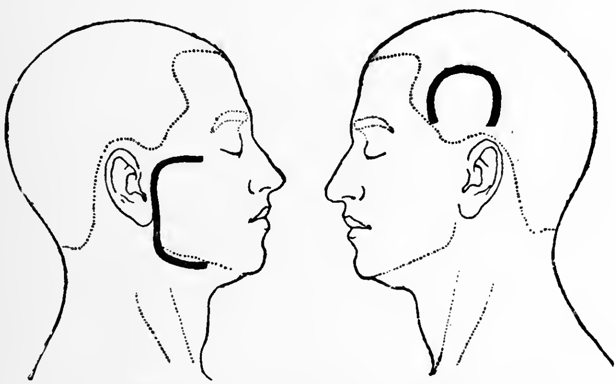

FIG. 220.—INCISIONS EMPLOYED IN THE REMOVAL OF THE GASSERIAN GANGLION.

The left-hand incision is that employed in the early operations by the pterygoid route; the scar causes much disfigurement, being situated wholly on the face. The right-hand one is placed above the zygoma, the scar being concealed by the scalp.

peripheral neurectomy. Stretching the branches of the fifth nerve is useless, and should never be performed. Exposure of the nerve-branch or nerve-trunk most concerned in the neuralgia and injection into it of solution of osmic acid or strong alcohol has been repeatedly tried, and the latter method has come into considerable vogue on the Continent. The injection of alcohol causes an inflammatory degeneration of the nerve, and may thus relieve the neuralgia, but it is an uncertain method, and is open to the objection that, like all forms of peripheral operation, there is little chance of permanent cure. The best results of the alcohol method (Schlösser's) have followed injection into the neighbourhood of the foramina ovale and rotundum. *See*

V. Harris (*Med. Soc. Trans.*, 1909) and P. Stewart (*Brit. Med. Journ.*, Sept. 29th, 1909). The injections are not free from risk—retrobulbar optic neuritis and paralysis of oculo-motor nerves having been occasionally produced. It is best to use light general anæsthesia when the needle is inserted.

EXCISION OF THE GASSERIAN GANGLION

This operation for the relief of trigeminal neuralgia appears to have been first suggested in print by J. Ewing Mears in 1884. The result of all the various operations on the branches of the fifth nerve, however extensive, was almost invariably the same—recurrence of the pain after an interval of relief. This disappointing fact led surgeons naturally to attack the intracranial portion of the nerve, in the hope that a more permanent cure might thus be obtained. This hope has fortunately been fulfilled, since evidence is steadily accumulating that after the Gasserian ganglion has been excised the neuralgia is once and for all done away with. This result, however, did not follow the first attempts to excise the ganglion, since the most difficult route was adopted to reach it—viz. by the pterygoid fossa, the roof of which was trephined in order to get at the ganglion from below.* This method involved a large wound at the side of the face, division of the zygoma and of the coronoid process, and most troublesome hæmorrhage from the branches of the internal maxillary artery.

The divided zygoma was subsequently wired in place, but it occasionally necrosed, and the Eustachian tube was apt to be damaged. But the most important objection to the operation was the very imperfect access it afforded to the ganglion—indeed, there is no doubt that many operators failed to reach or to deal adequately with it. In one such case operated on by a competent surgeon the neuralgia returned worse than ever, and I had the opportunity of performing a subsequent excision by the temporal route, finding the ganglion perfectly intact.

Sir Victor Horsley in 1891 (*Brit. Med. Journ.*, Nov. 28th, Dec. 5th and 12th, 1891) trephined the temporal fossa, divided the dura mater, and, having lifted up the brain from the middle fossa, succeeded in dividing the roots of the fifth nerve just below the pons Varolii. His patient unfortunately died of shock.

Early in 1892 the present method of approaching the Gasserian

* Professor W. Rose, *Lancet*, Nov. 1st, 1890; and subsequent Lettsomian Lectures to the Medical Society of London.

ganglion was devised independently by Mr. F. Hartley (*New York Med. Journ.*, vol. lv., 1892, No. 12) and Professor Krause (*Deut. med. Woch.*, 1893, No. 15). In their operation the ganglion is approached after trephining the floor of the temporal fossa and lifting up the dura mater until the second and third divisions of the fifth nerve are reached. Since this (the Hartley-Krause method) has been introduced, a large number of cases have been so treated by Sir Victor Horsley, Professor Krause, and others. Krause's monograph ("Die Neuralgie des Trigeminus," Leipzig, 1896) gives a full account of the subject, and the only important modification since it was written consists in the proof that in some cases ligature of the middle meningeal artery may be avoided as a formal step in the operation.

The reader may be referred to a work on "The Surgical Treatment of Facial Neuralgia," by J. Hutchinson, for fuller details than can be given in this place. The special instruments required, and the various steps of the operation are there illustrated.

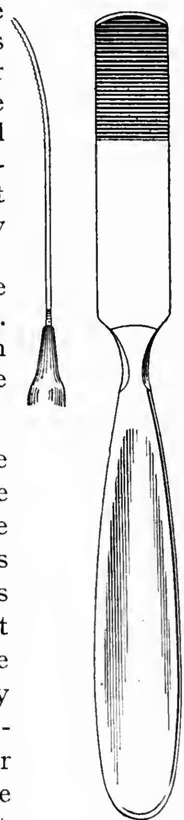

FIG. 221.—SPECIAL BROAD ELEVATOR.

Indications for the Operation.—It should be reserved for cases of very severe or inveterate neuralgia involving more than one division of the fifth nerve, and of the epileptiform type. It is understood that careful medicinal treatment has failed, but at the same time it is undesirable that the patient should have become the victim of the morphia habit, or that he should be worn out by prolonged suffering. Care should be taken to exclude cases in which there is a strong neurotic or hysterical element, for it is in these that failure to cure has chiefly resulted after the operation. It must be owned that this selection or exclusion is not easy, for long persistence of such pain tends to produce extreme mental depression or the neurotic state.

Age is no bar to the operation: most of its subjects are over fifty years, some of them over sixty. Indeed, I have found that, as a rule, the younger the patient the more difficult will the operation prove as regards controlling the hæmorrhage.

The risk of deformity after operation may be disregarded;

when properly performed, none results. The question of mortality has altered entirely since it was introduced; the early records gave 20 to 30 per cent. of deaths from the operation. I (J. H.) have performed it now over thirty times with no death.

Special Instruments Required.—To lessen both venous and arterial hæmorrhage, Krause recommends that the patient should be in the sitting posture in a dentist's chair; and with due care this will not increase the difficulty of the anæsthetist. Ordinary trephines and Hoffmann's bone-cutting forceps will suffice for making the opening in the skull, but some prefer to turn down a large flap of bone, in which case a rotatory saw worked by an electro-motor or dental machine, or Gigli's wire saw, will be necessary. It is essential to have a special broad elevator, made of flexible metal and mounted on a short handle, for lifting up the dura mater and brain. As it may be necessary to ligature the meningeal artery, an aneurysm-needle with a short curve, and of smaller dimensions than usual, should be at hand.

An electric head-lamp is essential, as the ganglion will be found at the bottom of a narrow wound at least 4 or 5 cm. deep. A number of suitable sponge-holders, not too large, must be provided. With these small pieces of the finest Turkey sponge, measuring from 1 to 2 cm. square, are held. A plentiful supply of these sponges should be prepared before the operation and duly sterilised. One assistant or nurse should see to the cleansing and renewal of the sponges, while the chief assistant will have charge of the retractor in one hand and will sponge with the other.

Landmarks of the Operation, etc.—When the cranial cavity has been opened, the foramen ovale is the first point to be made for. The foramen spinosum (transmitting the middle meningeal artery) is, however, placed externally to as well as slightly behind the larger foramen, and will therefore probably be reached first. A sufficient landmark for the two is the eminentia articularis on the zygoma, which is situated on the same vertical plane, 3 cm. externally to and slightly below them. There is never any need to divide the zygoma in the operation (as has been advised by Doyen and others), and its division adds both deformity and risk. The base of the flap to be turned down corresponds to the upper border of the zygoma, its posterior edge to the back

of the eminentia articularis. When the foramen ovale has been clearly defined, the foramen rotundum must be sought for 2 cm. in front.

It is assumed that the skin of the whole temporal region has been shaved and rendered aseptic.

The Operation.—A rounded flap, including all the tissues down to the bone, is cut with its base at the zygoma and its

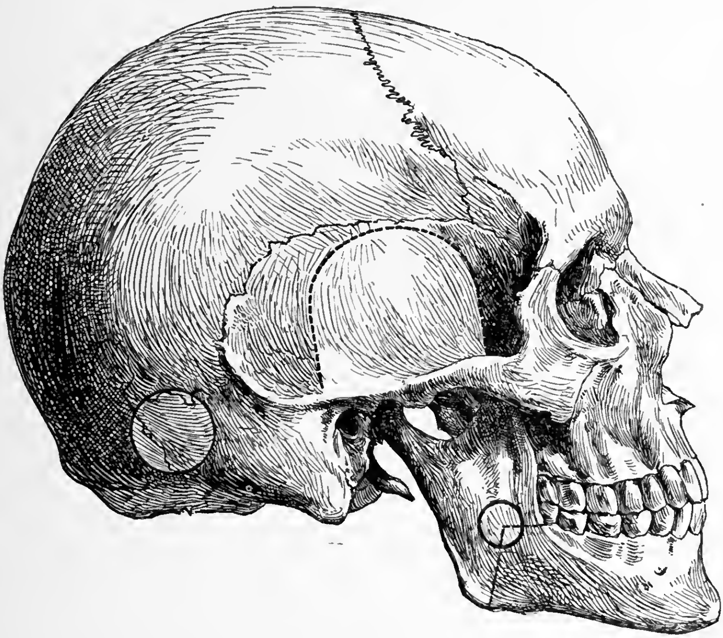

FIG. 222.—OPERATION OF EXPOSING THE GASSERIAN GANGLION.

The area of bone forming the temporal fossa necessary to be removed in order to expose the Gasserian ganglion is shown by the dotted line. The skin incision corresponds, but is somewhat larger. The two circles mark the trephine apertures for exposing the bend of the lateral sinus and the inferior dental nerve respectively.

upper edge 2 inches above this ridge. (*See* Fig. 222.) This flap lies over the front half of the squamous portion of the temporal bone, and the incision divides the branches of the temporal artery, which are at once secured by forceps. With the knife and periosteal rugine the flap is separated from the bone right down to the level of the infratemporal crest, that is corresponding to the zygoma. It is convenient to tie off both ends of the divided branches of the temporal artery, and to pass a suture through

the whole thickness of the flap. The two ends of the suture are not tied, but held in a Wells' forceps, and the flap is thus drawn well out of the way of the trephine. By means of a large trephine and cutting forceps the corresponding part of the cranial wall is removed, care being taken not to wound the dura mater or the meningeal vessels running in it. Even with the greatest care it is sometimes impossible to avoid piercing the dura mater, which varies remarkably in different individuals in its thickness and degree of adhesion to the bone. Fortunately a small puncture of the dura mater is not important, and may be disregarded. The disc of bone is not uniform in thickness, and this partly accounts for the risk of piercing the dura mater at one point of

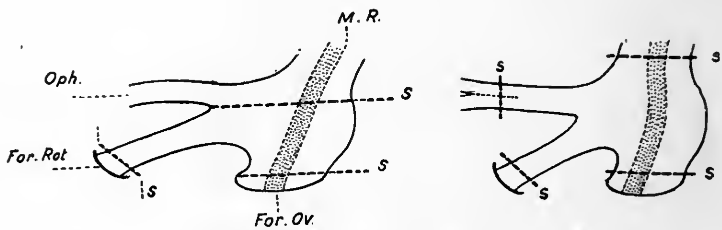

FIG. 223.—DIAGRAM OF THE GASSERIAN GANGLION.

The dotted tract M.R. is the motor root; Oph., the Ophthalmic Trunk; For. Rot, the aperture in the bone for the Superior Maxillary; For. Ov, the Foramen Ovale, through which Inferior Maxillary Division passes. The dotted lines SS, in the right-hand figure indicate the lines of section where the entire ganglion is removed; those in the left-hand figure S S, the ones made in the modified excision.

the trephine opening. The dura mater is now lifted upwards by an elevator, and the operator's finger, from the floor of the middle fossa, working directly inwards towards the foramen ovale and foramen rotundum, which are situated at a depth of about 3 cm., or $1\frac{1}{4}$ inches, from the wall of the temporal fossa. Sufficient bone must be removed to allow of the introduction of the broad bent spatula or elevator by which the assistant raises the temporo-sphenoidal lobe in its case of dura mater. The inferior maxillary nerve must be clearly defined as it passes through the foramen ovale, and at this point the middle meningeal artery is almost certain to require division. This latter is one of the most trouble-some steps of the operation, as it is difficult to pass an aneurysm-needle round the vessel at this depth. Small pieces of fine sponge on holders are used to check the bleeding, and it is necessary to wait from time to time until it ceases. In tying the meningeal

artery double knots of fine silk should be used, and the vessel divided between them; it then becomes easy to expose the inferior maxillary nerve and the lower edge of the ganglion. Working forwards for a distance of about half an inch, the foramen rotundum is reached and the two main divisions of the fifth nerve are exposed. By blunt dissection (the dura mater is thin here and closely adherent) the upper surface of the ganglion is denuded. The inferior and superior maxillary nerves are now

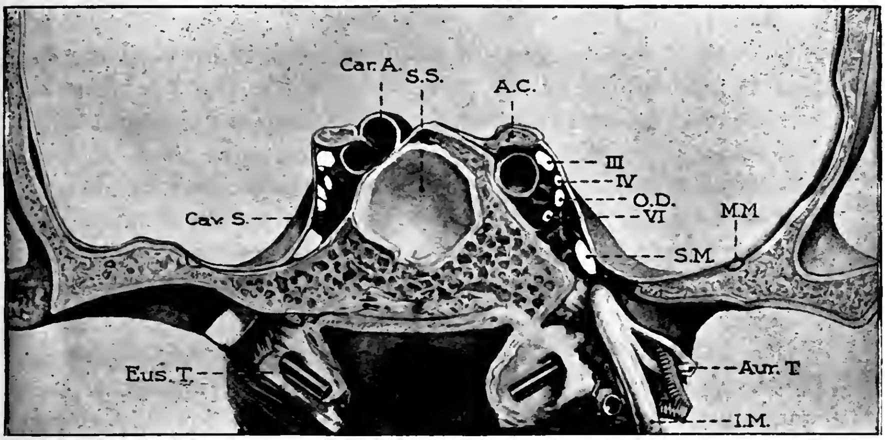

FIG. 224.—VERTICAL TRANSVERSE SECTION OF SKULL, SHOWING THE NERVES IN THE WALL OF CAVERNOUS SINUS (CAV.S).

III, IV, VI, Third, fourth, and sixth nerves; O.D., Ophthalmic division; S.M., Superior maxillary, and I.M., Inferior maxillary, divisions of fifth nerve; AUR.T., Auriculo-temporal nerve; CAR.A., Carotid artery; S.S., Sphenoidal sinus; A.C., Anterior clinoid process; EUS.T, Eustachian tube (with glass rod inserted); M.M., Middle meningeal artery.

cut across, just as they enter the foramina ovale and rotundum. The ganglion is now free at its lower border; it is gently isolated and drawn forward with fine serrated forceps, and its roots are divided. For this purpose a narrow-bladed tenotome is much more convenient than a scalpel. The close proximity of the cavernous sinus and the oculo-motor nerves must be borne in mind, and unless the neuralgia has definitely involved the supra-orbital region it is best not to attempt the removal of the ophthalmic division and the corresponding upper fibres of the root. Many cases have proved that complete section of the two main branches of the ganglion and the greater part of the ganglion itself suffices for a permanent cure. A small drainage-tube is

inserted and the flap sutured in place. It is unnecessary to put back any bone. Sometimes, however, a flap of bone has been turned downwards with the soft parts, a Gigli's saw being used by means of four small trephine apertures. This undoubtedly gives free access to the dura mater, etc.; and if this method be employed, there will be no resulting gap in the cranial wall.

It is, however, the fact that the aperture left by trephining becomes so completely filled up with bone in a year or two that it can no longer be detected. There is another reason in favour of the trephine rather than osteo-plastic resection. The bone forming the temporal fossa is thin, and deeply grooved in old subjects (and nearly all the patients for whom this operation is done are elderly), and in using the Gigli's saw, or chisel, etc., the dura mater is readily wounded. Although in the late stage of the operation this sometimes cannot be avoided, and the escape of cerebro-spinal fluid even facilitates access to the ganglion, at an early stage it is undesirable. One writer recommends a deliberate opening of the dura mater in order to let the fluid escape. It should, however, be avoided if possible.

Dr. Tiffany, who has collected full records of 108 cases (*Trans. of Amer. Surg. Assoc.*, 1896, page 1), agrees in preferring the trephine, and in excising only the lower part of the ganglion (avoiding the ophthalmic division).

Poirier's or Cushing's Method of Approaching the Gasserian Ganglion.—This is to a large extent a return to Mr. William Rose's original method. It was described and advocated by the late M. Paul Poirier some few years before Dr. Cushing, but is referred to in Kocher's "Operative Surgery" and elsewhere under the latter's name. Its steps are briefly as follows: 1. The flap is similar to but does not extend quite so high as the one already described; its base corresponds to the whole width of the zygoma. The latter piece of bone is cut through at either end and turned down with the flap. The masseter origin is not affected, though this matters little, as the muscle is sure to atrophy subsequently. An opening is now made in the temporal bone with a burr, and enlarged to 3 cm. with skull forceps, so as to include the infratemporal crest. The dura mater is detached as far as the foramina ovale and rotundum. "A blunt dissector is then inserted between the two foramina, and the dura is stripped off the upper

surface of the roots and the ganglion. . . . The under surface of the dura is then separated from before backwards along the second division until the ganglion is raised up. Lastly, the dura is separated internally where it is adherent to the sixth nerve and cavernous sinus, the separation being done from behind forwards towards the first division. The second and third divisions are now raised up on blunt hooks and cut across; the root of the ganglion is then seized with forceps and torn out along with the stump of the second and third divisions and the first division. . . . It is unnecessary to suture the zygoma, as it is better that it should sink in as the muscles of mastication atrophy."

There is, of course, in this method of operating, the same troublesome oozing from minute vessels, and a considerable risk of damaging the cavernous sinus in tearing away the ophthalmic division. It is stated, however, that Cushing only employs temporary packing to stop the hæmorrhage, and does not drain. In our opinion a small spiral or other drainage-tube, left in for 24 or 48 hours, has no possible objection, and is a valuable safeguard. Cushing's aperture in the skull is of necessity considerably smaller than that made in the temporal fossa, and this seems to be a drawback; on the other hand, the middle meningeal may not require ligature. We dissent entirely from the recommendation to tear away the ophthalmic division, and the sinking in and falling downwards of the zygoma which must result form Cushing's method is a distinct drawback. We prefer the Hartley-Krause method by the temporal route mainly on two grounds: it gives better access to the ganglion, and is followed by less deformity. Whichever method be adopted, we advise leaving the ophthalmic division untouched whenever practicable.

After-treatment.—In a prolonged and difficult operation of this kind faults in asepsis are apt to creep in, as shown by the fact that about half the fatal results are due to septic meningitis. At the end of the operation, therefore, the wound should be gently flushed with a weak warm antiseptic solution. There is always much oozing during the operation, and nothing could be worse than the collection of blood between the dura mater and the flap. Hence, whether the large trephine has been used or the osteo-plastic method, provision should be made for drainage

during the next forty-eight hours, and the patient's head should be turned on the affected side. A small spiral tube, removed in two days' time, will suffice. The head must be enveloped in a light dressing of sterilised gauze and wool, and for securing it an elastic bandage is useful. The wound should have healed in a week; but if bone has been replaced or the osteo-plastic method employed, it may happen that necrosis will occur.

When the ophthalmic division has been cut across, the cornea and conjunctiva will be left wholly anæsthetic (Fig. 225), and special precautions must be taken to guard against ulceration of the cornea of a low and destructive type. No strong antiseptic

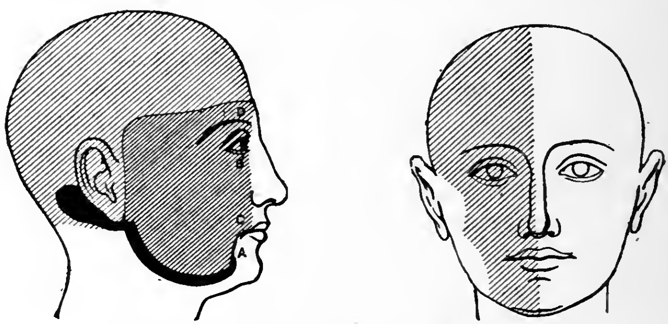

FIG. 225.—EXCISION OF THE GASSERIAN GANGLION.

The left-hand figure shows the area of pain in a case of trigeminal neuralgia. The black part is that in which most intense pain was felt, the lightly shaded scalp that which the pain invaded during the worst attacks (this area is not wholly supplied by the fifth nerve). A, B, C, D, Points of extreme sensitiveness before operation; slight pressure on them would at once cause violent spasmodic pain. The right-hand figure shows the anæsthetic area after complete removal of Gasserian ganglion.

solution should be allowed to come near the eye; a weak boracic lotion should be employed in case of conjunctivitis. Subsequently, protective glasses should be constantly worn to prevent access of dust. The cornea never regains sensation, and the lodgment of germ-laden particles of dust will hence always form a danger. For this reason, and also on account of the success of the operation limited to the two main divisions of the fifth nerve and the ganglion, the operator is advised to leave the ophthalmic trunk alone. If this advice be followed no precautions are required as regards the eye.

Post-operative shock may be considerable in these patients, who are usually aged and exhausted by their suffering, and it

has accounted for nearly half of the deaths recorded. In overcoming it, strychnia injections, brandy and coffee enemata, and warmth to the general surface are the chief remedies. In our experience, however, unless the operation has been attended with unusual difficulty from hæmorrhage, the shock has been, as a rule, but slight. This is probably due to the avoidance of the osteo-plastic methods, which considerably prolong the operation.

Complications and Results.—The direct mortality of this operation was at first undoubtedly high (20 to 30 per cent.), but it must be remembered that its subjects are usually reduced to a low ebb by prolonged suffering and the abuse of morphia. Moreover, the percentage of deaths just given was deduced from cases operated on when the procedure was still in an experimental stage. In some the fatal ending may fairly be ascribed to unsuccessful attempts to improve the method now followed. As already stated, my own experience of nearly fifty operations on the Gasserian ganglion has fortunately been unattended by a death. In a few of my cases the first or ophthalmic division has been deliberately or unavoidably destroyed, and in almost all of these some temporary or relapsing inflammation of the cornea or conjunctiva has resulted. In one only did destructive keratitis and iritis compel removal of the globe. In a few cases paralysis of the facial nerve, temporary or lasting, has followed removal of the Gasserian ganglion. This sequence is rather difficult to explain.

Temporary paresis of the opposite arm or leg has also been met with. In the great majority of my cases there has been no complication of any kind. I do not, however, wish to underestimate the gravity of the proceeding. The operation is, in any case, one of the most difficult to perform, and the surgeon who does it for the first time is apt to fall into one of two faults.

First, owing to the delay caused by hæmorrhage, and to his anxiety to finish the operation, he does not isolate the ganglion properly, but contents himself with cutting away something or scraping with a Volkmann's scoop at what he imagines should be the ganglion. Of course, in such a case failure and recurrence of the neuralgia are almost certain. The scoop cannot remove the ganglion, and should never be used for that purpose. When

persistent bleeding prevents the operator from clearly seeing the ganglion, he should close up the wound and resume the operation after a few days' interval.

Secondly, the surgeon, determined to make the operation complete by removal of the ophthalmic trunk as well as the rest of the ganglion, opens the cavernous sinus, damages the oculomotor nerves, or divides the thin dura mater freely.

The result of the operation when efficiently carried out contrasts strongly with that following peripheral neurectomy, excision of Meckel's ganglion, etc. The neuralgia is permanently cured; if it should return the operator has failed really to excise the lower part of the ganglion and its two main branches. With freedom from pain and recovery of sleep, etc., the patient improves in general condition in the most remarkable way.

The gravity of the operation will certainly be lessened by the adoption of two measures: (1) resorting to it before the patient is completely worn out by his pain, etc.; and (2) limiting the removal of the ganglion in the manner above described.

Operations on the Peripheral Branches of the Fifth Nerve

The only indication for such operations is severe neuralgia limited to the area supplied by one or other branch. As a rule the result of the operation, however thoroughly it be performed, is only relief for a few months. Simple division or neurotomy is useless, as the ends promptly join and the neuralgia returns. If a fair length of the nerve is exposed and excised the result is better, and the most radical method is that advocated by the late Prof. Thiersch. In this the nerve is well exposed and divided, the distal end is seized with pressure forceps and is forcibly dragged out. It is surprising how long a piece of nerve with its branches can thus be torn away—as illustrated in Prof. Krause's monograph on Trigeminal Neuralgia. It is, however, doubtful whether the relief afforded by evulsion is any greater than that which follows a clean excision of half an inch or one inch of the nerve.

During the last two or three years the plan of injecting pure alcohol into the nerve-trunk has been extensively tried, a sclerosing

neuritis is set up, and generally the nerve concerned remains paralysed for long, if not permanently. We do not think this procedure, which is closely akin to a former one of injecting osmic acid solution into the nerve, is likely to succeed in the cases of true epileptiform neuralgia, but it is too early to speak with certainty as to this. (*See* discussion on page 75.)

Although all operations on the peripheral branches of the fifth nerve are very doubtful as to permanency of result in severe neuralgia, we have retained the description of the various methods for their exposure.

FIRST DIVISION OF THE TRIFACIAL NERVE

The Supra-Orbital Nerve.—*Anatomy.*—This nerve escapes through the supra-orbital notch, and ascends vertically. The notch is situated at the junction of the middle with the inner third of the upper orbital margin. At this spot the nerve lies beneath the orbicularis palpebrarum and is usually found to have already broken up into two divisions. It is accompanied by the supra-orbital vessels, which lie to its outer side.

Operation.—The eyebrow is steadied by the operator's left hand while an assistant draws the eyelid downwards. An incision about three-quarters of an inch in length is made horizontally along the superior orbital margin in such a way that its centre will correspond to the supra-orbital notch. The integuments and orbicularis muscle having been cut through, the nerve is readily exposed. The vessels should be avoided.

Comment.—A vertical incision exposes more of the nerve, and is simpler, but it makes a more considerable section of the muscle and leaves a larger scar.

SECOND DIVISION OF THE TRIFACIAL NERVE

Anatomy.—The superior maxillary nerve pursues a nearly horizontal course from the foramen rotundum to the infra-orbital foramen on the anterior surface of the upper jaw. If the course of the nerve be followed, the distance between these two foramina is, in the adult skull, about two inches.

At the infra-orbital foramen the nerve breaks up into its ultimate cutaneous branches, viz. the palpebral, labial, and nasal (Figs. 226 and 227).

A little beyond the foramen rotundum the nerve crosses the spheno-

maxillary fossa, and at the spot where it bridges over this fossa Meckel's ganglion is found.

The distance from the infra-orbital foramen (on the face) to Meckel's ganglion can seldom be less than $1\frac{3}{4}$ inches.

The following is the guide for the infra-orbital foramen. A line is drawn downward from the supra-orbital foramen (page 87) so as to cross the gap between the two bicuspids in both jaws. This line will cross both the infra-orbital and the mental foramina. The former is just above the canine fossa and about a quarter of an inch below the margin of the orbit.

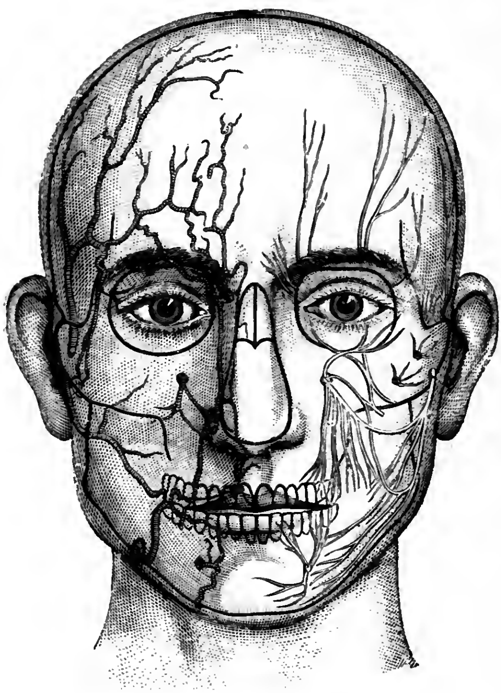

FIG. 226.—NERVES OF THE FACE AND THEIR RELATIONS TO THE ARTERIES OF THE REGION. (*From Meckel.*)

Meckel's ganglion is a triangular body with a diameter of about one-fifth of an inch. It is surrounded by the terminal branches of the internal maxillary artery, and has the following relations. Above it is the superior maxillary nerve, behind it are the sphenoid bone and the Vidian canal, on its outer side are the termination of the internal maxillary artery and the external pterygoid muscle, and on its inner side are the vertical plate of the palate bone and the spheno-palatine foramen.

As this nerve is often dealt with in the treatment of neuralgia involving the upper teeth, the position of its branches is important. Within the skull it gives off the recurrent branch to the dura mater. Between the foramen rotundum and the ganglion comes off the orbital branch. Between the ganglion and the superior maxilla, i.e. at the point of entrance into the infra-orbital canal, arises the posterior dental branch, which supplies the molars. At the hinder part of the canal and within the maxilla takes origin the middle dental nerve,

which supplies the bicuspid and canine teeth. The incisor teeth are supplied by the anterior dental nerve, which arises at the anterior part of the canal close to the infra-orbital foramen.

In order, therefore, that all the dental nerves may be severed, the nerve trunk must be divided as far back as Meckel's ganglion.

The posterior half of the infra-orbital canal is open to the orbit, and exists as a groove merely; the anterior half has a bony roof,

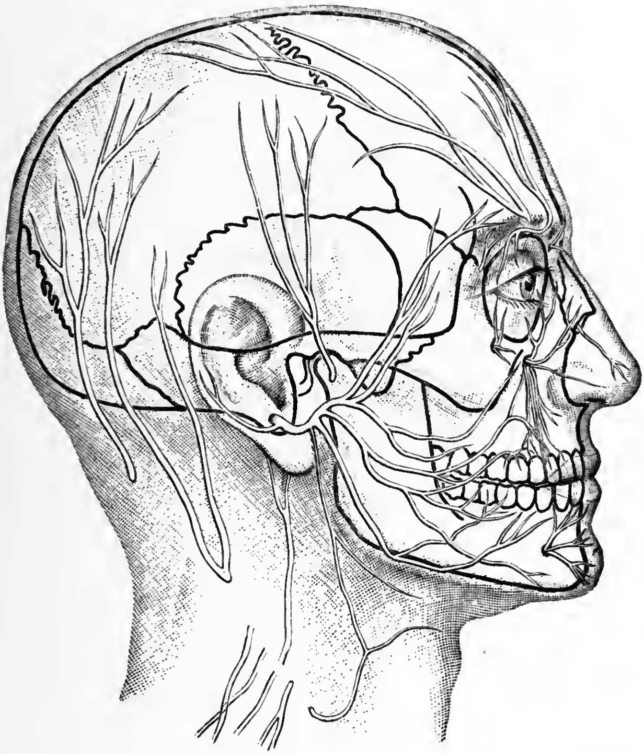

FIG. 227.—NERVES OF THE FACE AND OF THE SIDE OF THE HEAD. (*From Meckel.*)

and takes therefore the form of a genuine osseous canal. Occasionally the whole or part of the posterior portion of the so-called canal has a bony roof, and in such case no part of the nerve could be exposed from the orbit without cutting through a thin plate of bone.

The infra-orbital vessels which accompany the nerve in the infra-orbital canal are small and have an inconstant relation to the nerve, although they more usually lie to its outer side.

1. **The Infra-Orbital Nerve.**—*Surface Operation.*—This nerve as it leaves the infra-orbital foramen may be exposed by means of a transverse incision three-quarters of an inch in length made about a quarter of an inch below the lower margin of the orbit, and so placed as to cross the infra-orbital foramen (Figs. 226 and 227).

After the skin, layer of subcutaneous fat, and orbicularis muscle have been divided, the levator labii superioris is exposed, and must be severed in the line of the original wound. The nerve is now reached, and can be dealt with. The parts are vascular, and the view of the nerve is apt to be occluded by free bleeding.

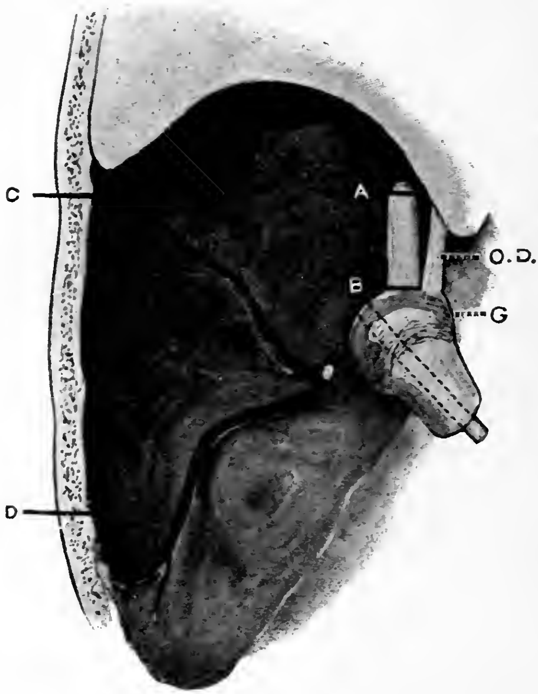

FIG. 228.—INTRACRANIAL RESECTION OF THE SUPERIOR MAXILLARY NERVE.

A, B, Portion of the nerve to be excised; C, D, Wall of temporal fossa; O.D., Ophthalmic division; G., Gasserian ganglion.

Comment.—Section of the nerve at this spot cuts off merely the terminal branches to the face.

In order to reach the superior maxillary nerve where it gives off the branches to the palate, teeth, and upper jaw, various procedures have been devised for obtaining access to the pterygo-maxillary fossa, the so-called operations is on Meckel's ganglion. They are so difficult and so disappointing that we omit their description in favour of an operation which reaches the superior maxillary nerve before it has given off any branches at all.

Intracranial Resection of the Superior Maxillary Nerve.—This should be reserved for cases of severe neuralgia involving the distribution of the superior maxillary alone.

The method of approaching the nerve is exactly the same as for the Gasserian ganglion (*see* pages 79 *et seq.*), by trephining the floor of the temporal fossa, elevating the dura mater, etc. The operator, however, aims at the front part of the middle cerebral fossa, finds the nerve at the foramen rotundum and traces it back to the ganglion. It will probably be unnecessary to ligature the middle meningeal artery, as the dura mater can be sufficiently raised without this. The nerve, being isolated, is very carefully cut through at the foramen rotundum, the divided end drawn outwards with fine forceps, and again divided close to the ganglion. In this way from one-third to half an inch can be resected. The procedure is certainly better (i.e. more thorough) than neurectomy performed from the face, but whether it will retain a place in surgery is doubtful. I (J. H.) have had the opportunity of performing it twice only. In one case it was a complete and permanent success, the neuralgia being at once cured and not recurring when the patient was last seen, five years later. In the second case, however, the relief lasted only about a year, and then the epileptiform neuralgia returned in the third division of the fifth nerve and required excision of the Gasserian ganglion. It should be noted that the distribution of the superior maxillary remained anæsthetic and free from pain, and that the major operation on the ganglion was rendered actually easier by the previous one.

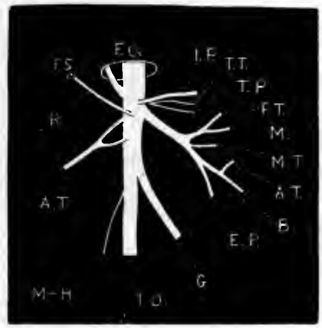

FIG. 229.—DIAGRAM OF THE THIRD DIVISION OF THE FIFTH NERVE.

F.O., Foramen ovale (below this the motor root joins the nerve); F.S., Foramen spinosum; R, Recurrent branch; A.T., Auriculo-temporal nerve; M.H., Mylo-hyoid nerve; I.D., Inferior dental nerve; G., Gustatory nerve; E.P., External pterygoid branch; B., Buccal nerve; A.T., Anterior temporal nerve; M.T., Middle temporal nerve; M, Masseteric nerve; P.T., Posterior temporal nerve; T.P., Branch to tensor palati; T.T., Branch to tensor tympani; I.P., Internal pterygoid branch.

THIRD DIVISION OF THE TRIFACIAL NERVE

1. **The Trunk of the Nerve at the Foramen Ovale.**—*Anatomy.*—The nerve on leaving the foramen ovale is immediately joined by the motor part of the fifth nerve (Fig. 229). A little way below the foramen the nerve breaks up into two divisions, an anterior small or upper division, and a posterior large or inferior division. From the trunk arise four nerves—the recurrent branch to the dura mater, which enters the skull through the foramen spinosum; the internal

pterygoid nerve ; and the nerves to the tensor tympani and tensor palati.

From the anterior division arise four nerves, the temporal (anterior, middle, and posterior) ; the masseteric (from the posterior temporal) ; the buccal (with the anterior temporal) ; and the external pterygoid (Figs. 229, 230, and 231).

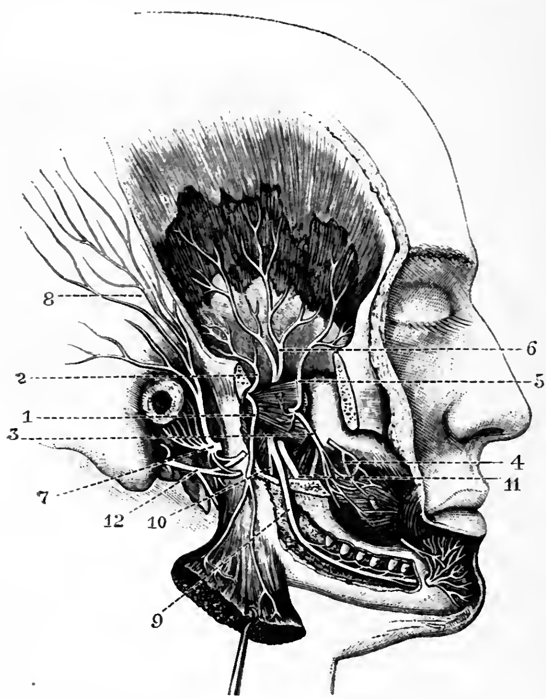

FIG. 230.—THIRD DIVISION OF THE FIFTH NERVE.
(*After Hirschfeld and Leveille.*)

1, Masseteric nerve ; 2, Posterior temporal nerve ; 3, Buccal nerve ; 4, Branch to facial nerve ; 5, Anterior temporal nerve ; 6, Middle temporal nerve ; 7, Auriculo-temporal nerve ; 8, Its temporal branches ; 9, Inferior dental nerve ; 10, Mylo-hyoid nerve ; 11, Gustatory nerve ; 12, Facial nerve.

From the posterior division also arise four nerves, the auriculo-temporal, the gustatory, the inferior dental, and the mylo-hyoid.

The Inferior Dental Nerve.—*Anatomy.*—This nerve, the largest branch of the third division of the fifth, descends under cover of the external pterygoid muscle, passes to the outer side of the internal pterygoid, and running between the internal lateral ligament and the ramus of the jaw, enters the dental foramen (Figs. 230 and 231).

This foramen is surmounted by a prominent and usually sharp projection of bone, the lingula or spine of Spix. To its apex is attached the internal lateral ligament of the jaw, while below and behind it is the groove for the mylo-hyoid nerve.

The internal pterygoid muscle reaches to the base of the lingula.

The nerve is accompanied by the inferior dental artery, which lies behind and externally to it.

Neurectomy of the Inferior Dental Nerve through a Trephine Aperture in the Lower Jaw.—The point of bone to be aimed at is indicated on the ascending ramus by the meeting of two lines—one perpendicular to the lower border of the jaw passing upwards from its angle, the other a continuation backwards of the alveolar margin (Fig. 222). This point on the side of the cheek is well below the parotid duct and behind the facial vein; the skin incision of one inch should be mainly horizontal, to avoid injury to the facial nerve, but it is convenient to curve it slightly. The masseter being exposed, its fibres are partly severed, but chiefly separated, until the bone is reached and bared with a periosteal elevator.

The pin of a small (half-inch) trephine is then inserted exactly at the spot above-mentioned, and when the outer table of compact bone is traversed the disc is removed by means of the elevator. It is almost certain that the groove containing the inferior dental nerve and vessels will be opened thereby, and it should very carefully be cleared on either side with a small chisel or bone-cutting forceps. The groove should be followed upwards and downwards, with due caution not to injure the inferior dental artery, until the nerve can be raised alone on a hook. With Thiersch's forceps a long piece of both ends of the divided nerve can sometimes be drawn out; if not, as much should be cut away as possible. The bone disc need not be replaced, and two or three fine sutures will suffice for the wound, which heals rapidly. The patient should be kept on liquid or soft food for a few days.

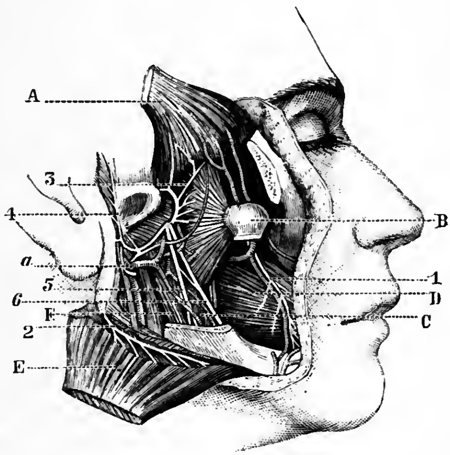

FIG. 231.—DISSECTION OF THE THIRD DIVISION OF THE FIFTH NERVE. (*Ellis's Dissections.*)

A, Temporal muscle; B, Condyle of jaw; C, Internal pterygoid muscle; D, Buccinator; E, Masseter; F, Internal lateral ligament; *a*, Internal maxillary artery; 1, Buccal nerve; 2, Masseteric nerve; 3, Temporal nerve; 4, Auriculo-temporal nerve; 5, Inferior dental nerve; 6, Lingual nerve.

The success of the operation depends chiefly on exactly following the landmarks given, and avoiding injury to the companion artery. As a rule, the dental nerve lies just in front of the latter, and is readily distinguished, once the canal is opened, by its whiter colour.

After this neurectomy the pain is, as a rule, entirely absent for one, two, or more years, but it is exceptional for no recurrence of any kind to be experienced. It may be noted that immediately after the operation, for a few days, the patient will complain of aching, due to the traction of the proximal end.

OPERATIONS UPON THE FACIAL NERVE

These are of two kinds: in one the nerve is stretched for the relief of spasmodic tic, in the other the paralysed nerve is anastomosed with a near-lying cranial nerve in the treatment of persistent facial paralysis (nerve-anastomosis).

In both cases the facial nerve is exposed in the parotid region after it has left the stylo-mastoid foramen, and it will be convenient to consider the anatomical relations of the nerve in this position.

The point of emergence of the seventh (facial) nerve from the base of the skull lies at the depth of nearly an inch (two centimetres) from the surface; it corresponds to the front edge of the mastoid process and the posterior border of the external auditory meatus. Immediately on leaving the stylo-mastoid foramen the nerve gives branches to the digastric and stylohyoid muscle, and is then directed downwards, forwards and outwards through the substance of the parotid gland to the ascending ramus of the lower jaw. A little behind this it divides into two main parts, the temporo-facial and cervico-facial. Both these curve round the ramus of the jaw, the temporo-facial being directed forwards and a little upwards, the cervico-facial mainly downwards. Both divisions are in intimate relation with that part of the parotid gland which overlaps the jaw. The intricate network of communicating branches of these two divisions over the masseter muscle forms the pes anserinus.

The main trunk of the nerve, on which the surgeon operates, is quite short (about one inch long); it lies towards the top of the parotid fossa, and its main direction is forwards and outwards.

Operation for Exposure of Facial Nerve.—The lobule of the ear being held well upwards, the operator makes a curved incision ($1\frac{1}{2}$ inches long) which starts at the border of the mastoid process just below the ear, and which follows the anterior edge of the sterno-mastoid muscle for an inch, then curving forward

towards the jaw. The edge of the sterno-mastoid muscle being exposed and retracted, the parotid lobules are carefully separated from their fascial sheath and held forwards. With a little blunt dissection the facial nerve can hardly fail to be exposed if its direction be remembered. The styloid process will easily be felt, and the point of emergence of the nerve between the base of this process and the digastric muscle will be a useful landmark.

"The line for the nerve is exactly parallel with the upper border of the digastric muscle" (R. J. Godlee).

The knife should be used with great care, lest the facial nerve itself be divided. As Dr. Keen advises (*Trans. of the Amer. Surg. Assoc.*, vol. iv.), a weak faradic current may be employed to identify the nerve. A wet sponge connected with one electrode is held to the cheek, and a fine wire connected with the other is applied to various points in the wound until the nerve are found. In this way needless injury and disturbance of parts are avoided. There may be a good deal of both arterial and venous bleeding during the dissection; for instance the posterior auricular vein may be divided. An electric head-lamp may be found useful.

Once the nerve is isolated at one point, and held on a blunt hook, it is easy to trace it forwards and backwards.

If the operation is one of **nerve-stretching for spasmodic tic,** it is recommended that the force be employed centripetally, and that its amount be only limited by the strength of the nerve, the stretching being discontinued the moment any fibres give way (Keen). Mr. R. J. Godlee, who was the first to perform this operation in England (*see* cases reported in the *Clin. Soc. Trans.*, vols. xiv. and xvi.), in one case noticed that spasmodic twitching of the facial muscles increased on first raising the nerve, and that vigorous stretching left them flaccid and paralysed.

This paralysis, which must be secured for a time if the operation is to be of any use, usually disappears gradually in the course of a few weeks or months.

Unfortunately it appears that, as a rule, the spasmodic tic recurs not long after the return of function in the facial nerve. Dr. Keen (*loc. cit.*) collected twenty-one cases operated upon, starting from Baum's, the first recorded one, and in only five of these did the relief last for more than a year. Mr. Southam,

however, had one most successful case, in which the patient was perfectly well at the end of five years. Hence in cases of spasmodic tic in which marked distress is produced the operation of stretching the facial nerve still seems worthy of trial.

Nerve-anastomosis for Facial Paralysis.—In complete facial paralysis from chronic ear disease, etc., when no chance of spontaneous recovery appears probable, the nerve may be exposed in the manner already described, and joined on to another motor cranial nerve. The spinal accessory and the hypoglossal nerves are the two which have been mainly used in the "anastomosis." The facial trunk is completely divided, and its distal end implanted into the proximal portion of one or other of the two nerves mentioned, which has been carefully exposed and either partially or completely divided for the purpose.

If possible, implantation into the partially divided nerve should be carried out, otherwise the result may be very disappointing. Thus Mr. J. H. Nicoll (*Lancet*, Oct. 3rd, 1903) joined the facial nerve with the proximal end of the divided hypoglossal with no improvement to the facial paralysis, whilst one half of the tongue became paralysed!

The literature of the operation is already large, but the exact value of the proceeding is still somewhat doubtful. Series of cases will be found in papers by Messrs. C. A. Ballance, H. A. Ballance and Stewart (*Brit. Med. Journ.*, May 3rd, 1903); by Dr. Cushing (*Annals of Surgery*, 1903, No. 5), Hachenbruch (Langenbeck's *Arch.*, Bd. 71, Heft 3), and Käte (*Deuts. med. Woch.*, 1903, No. 17).

Besides the spinal accessory and hypoglossal nerves the glosso-pharyngeal has been occasionally used to connect with the paralysed facial nerve.

Messrs. Ballance (quoted in Jacobson and Rowland's "Operative Surgery," vol. ii., p. 418) consider that "when facial paralysis has lasted six months, no recovery is to be expected, and the sooner the operation is performed after this date the better."

The gain to be expected from the operation may be summarised thus: 1. The flaccidity and deformity of the affected side of the face slowly diminish, especially when the muscles are at rest. 2. In a few cases some power over the active contraction of the facial muscles returns, and if the cerebral centres become, so

to speak, educated, voluntary control over some of these muscles may be regained.

At the same time when implantation has been done, e.g. into the spinal accessory nerve, the patient may only succeed in contracting the facial muscles when he at the same time moves the shoulder.

The drawbacks to operation of complete end-to-end anastomosis are: 1. The muscles supplied by the joined-up nerve are, at any rate for a time, paralysed. Thus the trapezius and sterno-mastoid will be partially disabled if the spinal accessory has been divided, and half of the tongue will atrophy if the hypoglossal has been used for the anastomosis. 2. In some cases the extravagant movements of other muscles associated with the attempt to contract the formerly paralysed facial ones raise doubt as to the condition being preferable to that before operation.

Although Messrs. Ballance suggest that the glosso-pharyngeal is after all the best nerve to select for facial anastomosis, too few cases of this have been recorded to enable us to judge as to its value. The glosso-pharyngeal is to so slight an extent a motor nerve that one would doubt its applicability.

At any rate, nearly all surgeons who have reported cases of facial anastomosis have selected either the hypoglossal or the spinal accessory.

Operative Procedure.—This has varied much, and it is impossible to lay down definite rules. An incision along the anterior border of the sterno-mastoid for three inches from its upper insertion may be used to expose the back of the parotid gland, and the outer surface of the digastric muscle. The facial nerve is sought for in the way described above (page 94), and is then cut through, a fine suture being placed in its distal portion. Beneath the lower edge of the digastric muscle the spinal accessory nerve, which runs downwards and backwards towards the sterno-mastoid, is then sought for. The sterno-mastoid should be retracted to facilitate this. Either part or the whole of the latter nerve is then brought up after division over the digastric and joined by very fine silk sutures, which involve mainly the sheaths, to the already isolated distal end of the facial.

Galvanism may be used after the wound is healed.

As already noted, improvement must be slow, and many months may elapse before a satisfactory result is attained. If the hypoglossal nerve be utilised the procedure will differ but little, the nerve being exposed beneath and below the digastric muscle, divided and brought up to the facial. Messrs. Ballance consider the hypoglossal preferable for the purpose to the spinal accessory, because of the frequent association of movements of the tongue with those of the face. On the other hand, paralysis of one half of the tongue is a distinct drawback.

RESECTION OF THE POSTERIOR CERVICAL NERVES

In the treatment of spasmodic torticollis the spinal accessory nerve alone was formerly stretched or divided. Since the spasm is not confined to the sterno-mastoid and trapezius muscle, but almost always involves the suboccipital, splenius, complexus, and trachelo-mastoid muscles, this operation gave very poor results. The late Prof. Gardner of Adelaide, and Prof. Keen of Philadelphia, about 1890 devised independently a more radical operation which included resection of the posterior branches of the first four cervical nerves.

The procedure is a very severe one, involving a deep and difficult dissection at the back of the neck which is attended with considerable hæmorrhage. Nevertheless the results have been encouraging in properly selected cases, and the condition of confirmed spasmodic torticollis is such a distressing one that the operation is quite justified.

The following are the **steps of the operation,** the back of the scalp having been shaved and the skin rendered aseptic, and the patient turned over almost prone.

1. A transverse incision is made from the mastoid process on the affected side to the occipital protuberance.

2. An oblique incision is made from the mastoid process to the spinous process of the sixth cervical vertebra. The triangular flap thus marked out is dissected up close to the muscles, and is turned inwards as far as the middle line. A stitch retractor for this purpose is passed through the flap and held by the assistant.

3. The anterior edge of the sterno-mastoid is then defined just below the skull, and the occipital artery and spinal accessory nerve (the latter the deeper of the two) are sought for. The

artery is ligatured in two places and divided, a piece of the nerve being then excised.

4. The upper end of the trapezius is divided transversely and held aside. The posterior border of the sterno-mastoid is held forwards or divided. The splenius capitis and complexus are in turn divided and drawn downwards. Before division of the complexus Mr. Tubby advises that its inner or vertical border should be defined and the finger passed beneath the muscle. Branches to it of the suboccipital nerve should be sought for on its deep surface and excised.

5. The suboccipital triangle is now exposed. At the lower border of the inferior oblique muscle the large second cervical nerve is seen and dissected out. Just below the vertebral artery the first or suboccipital should be sought for and treated in the same manner. Venous hæmorrhage is apt to be most troublesome, and care should be taken not to wound either the vertebral artery or vein.

6. Lower down the posterior branches of the third and fourth cervical nerves are readily found and divided. The nerve supply of the trachelo-mastoid should be cut off.

It will be understood that the nerves should not simply be divided: as much as possible of their trunks should be dissected out.

The method given above differs slightly from that usually described in that the spinal accessory nerve is specially dealt with as well as the cervical nerves. This is, however, an important step. It should be noted that whilst the spinal accessory as a rule lies superficially to the internal jugular vein, it occasionally passes beneath it.

7. Before the wound is sewn up it is well to unite the divided muscles one by one by a few kangaroo-tendon or catgut sutures.

A drainage tube should be inserted and a dressing firmly applied.

Operations upon the Cervical Sympathetic Trunk and Ganglia.—Very brief mention must suffice for these operations, which consist in excision of more or less of the sympathetic nerve trunk, with its upper and middle ganglia. The proceeding has been tried by many surgeons for three distinct conditions, exophthalmic goitre, epilepsy, and chronic glaucoma.

M. Jaboulay of Lyons, and Prof. Jonnesco of Bucharest, have been especially prominent in advocating and performing these operations. For epilepsy and glaucoma excision of the cervical sympathetic offers no special difficulty except an elaborate dissection behind the main vessels of the neck. In exophthalmic goitre, however, the operation is both difficult and dangerous. Von Eiselsberg remarks that "the dangers of this operation are at least as great as those of strumectomy" (i.e. partial removal of the thyroid gland) "if not greater."

The results in all three diseases have proved so disappointing and unsatisfactory that it is very doubtful if the operation will retain a place in surgery. The few cases where benefit has seemed to result may well have recovered in spite of, and not owing to, the operation.

THE BRACHIAL PLEXUS IN THE NECK

This plexus—formed by branches from the four lower cervical and the greater part of the first dorsal nerves—lies between the anterior and middle scalene muscles, and crosses the floor of the posterior triangle of the neck. The plexus is of triangular outline, the base being at the spine and the apex to the outer side of the subclavian artery below the clavicle. In thin subjects, when the shoulder is depressed and the head turned to the opposite side, some cords of the plexus can be felt through the skin.

Operation to Expose the Plexus.—The position of the patient should be the same as is assumed in ligaturing the third part of the subclavian artery (*see* page 366).

The plexus may be reached by a vertical incision, some three inches in length, which, commencing about half an inch above the centre of the clavicle, is continued upwards through the lower part of the posterior triangle. The wound will be parallel with the anterior border of the trapezius, and will be but little removed from the sterno-mastoid muscle. To this incision it is well to add a horizontal one running above the clavicle, the flap being then turned backwards.

The integument and platysma having been divided, the external jugular vein must be sought for, secured between two

ligatures, and severed. It is possible that in some instances the vein may be left untouched, and may be merely drawn downwards and inwards out of the way. The supraclavicular branches of the cervical plexus will be encountered.

The deep cervical fascia must in the next place be divided in the full length of the incision.

If the finger be now introduced into the depths of the triangle the cords of the plexus will be felt, and can be exposed by a little careful dissection. The clear outer border of the anterior scalene muscle should be defined. The omo-hyoid muscle will be exposed in the lower part of the incision, and should—if necessary—be drawn downwards.

The superficial cervical artery and vein cross the plexus transversely about its middle, and must be carefully sought for and protected. If the finger be passed along the plexus to the interval between the anterior and middle scalene muscles, there is no difficulty in identifying any particular cord.

Indications for Operating on the Brachial Plexus, and Results.—Many attempts have been made to suture a torn brachial plexus, but so far as we can ascertain, in no single case has marked benefit resulted (when the tear has been complete). As I (J. H.) found in two operations of this kind, the rupture occurs close to the spinal cord, and hence, although the distal ends can be identified and isolated, there is nothing to suture them to. In one case in which a single cord of the brachial plexus had been divided by a stab, the operation of suture at a later date was successfully carried out, though nine months elapsed before the functions returned. Several cases of removal of tumours pressing upon or lifting up the brachial plexus have been recorded; in most the so-called exostosis has really been a cervical rib. Tumours which infiltrate the plexus are not worth operating upon.

Bardenheuer (*Münch. med. Woch.*, 1903, No. 18) records one of the most successful operations on the brachial plexus yet reported. A stab-wound above the clavicle had divided two of the cords so that the median, musculo-spiral, and ulnar nerves were in great part paralysed. The result of operation performed a fortnight after the accident was a gradual and almost complete recovery of power in the muscles, etc.

There is no doubt that in order to offer any prospect of success in such cases the operation must be carried out at the earliest moment, before tough scar tissue has formed.

Kennedy (*Brit. Med. Journ.*, Feb. 7, 1903) records three cases of operation on young children for injury to the brachial plexus, with slightly encouraging results. As a rule, traumatic lesions of the plexus at the time of birth are recovered from without operation.

CHAPTER IV

PLASTIC OPERATIONS ON THE HEAD AND NECK, INCLUDING THOSE FOR HARE-LIP AND CLEFT PALATE

I. General Principles and Methods

Plastic surgery concerns itself with the remedy of certain congenital defects and malformations, such as hare-lip and cleft palate, and with certain acquired defects and deformities, such as may follow the loss of parts by injury or ulceration, or the contraction incident to the formation of cicatrices.

The great majority of plastic operations in the latter class are performed on the tissues of the face and neck, since lupus and rodent ulcer especially affect this region; and in no part of the body is the improvement or cure of disfiguring contraction by scar of more importance.

The principles and methods of repairing congenital malformations, such as cleft palate, are closely similar to those for acquired deformities of the skin, etc., and therefore the two classes will be considered together.

Certain plastic operations on the bladder and urethra and ureter have been already described in Vol. I. (pages 600-36, 556-7).

General Principles.—1. The common feature which underlies plastic surgery, as the term is usually understood, involves the ready and secure union of refreshed or divided surfaces. The operations for the most part concern the skin, and are dependent upon the vascularity and elasticity of the skin, its mobility, the readiness with which wounds made in it unite, and the comparative ease with which it may be displaced, and with which it moulds and adapts itself to a new situation.

2. In the actual planning of incisions and the mapping out of flaps, little can be done by following blindly any special method. Each case must be considered upon its merits, and

each operation arranged as the needs of the particular case suggest. No branch of operative surgery demands more ingenuity, more patience, more forethought, or more attention to detail. In connection with certain operations it may almost be said that no two cases are alike.

3. As sound and rapid healing is essential in these operations, it is of primary importance that the patient be in the best possible health, and that the tissues in the operation area be free from disease. Scar tissue can never be relied upon, and it is needless to speak of the recklessness of plastic operations in the vicinity of active syphilitic disease, or of lupus, or in aged or broken-down subjects. In many cases the operation cannot be repeated : there is little before the surgeon but success or a condition more lamentable than mere failure. A plastic operation may leave the deformity in a worse condition than it was before the case was approached, and before the prospects of success are compromised the surgeon should be convinced that no possible element of failure has been overlooked.

4. In planning the flaps it is necessary that they be derived from sound tissues, that they be thick and include the subcutaneous tissue, that their vascularity be assured, and that they be so cut as to inflict the least possible damage upon the arteries which supply them.

The flap must be large enough, and as a rule should be one-sixth larger than the space it has to fill ; it must be gently handled, carefully adjusted, and most tenderly and precisely sutured. The pedicle of the flap must not be so twisted or extended as to occlude the nutrient vessel. It is of the utmost importance that there be no undue tension upon the parts, and that the edges of the wound be not merely dragged together.

5. The margins of any surfaces of skin which are to be brought together must be evenly and liberally freshened. Throughout the whole progress of the case the strictest antiseptic precautions must be carried out, and the minutest care must be paid to the after-treatment.

In most cases union by first intention is aimed at, but, as is mentioned in a later section, this object may not be essential in all instances.

Methods.—The following are, very briefly, the chief methods made use of in plastic surgery. They must not be considered to represent either a complete system of operations or a series of rigid formulæ, but rather to form the groundwork of such varied procedures as the different classes of cases to be dealt with demand.

1. DIRECT UNION OF FRESHENED EDGES WHICH ARE BROUGHT TOGETHER, ALL TENSION UPON THE PARTS HAVING BEEN RELIEVED

This is applicable to small sinuses and fistulæ, to narrow linear and spindle-shaped gaps or fissures, and to such defects as the simpler forms of hare-lip.

The margins of the fissure or opening are freshened by removing the integument which covers them. The strip of skin to be removed is grasped and steadied with fine-toothed forceps, while the strip is severed with a narrow scalpel or sharp-pointed tenotome. The portion removed should include not only the skin, but also the subcutaneous tissues, and must be so free that the raw edges which are to be united are made out of sound and vascular structures.

The edges of the fresh wound are carefully cleaned, bleeding is checked by the pressure of a sponge, and finally the margins are approximated by fine silkworm-gut, horse-hair, or silk sutures.

It is often well to leave the wound open for a while, to allow time for any bleeding to cease before the sutures are finally adjusted.

In the case of larger gaps, or of fissures in dense tissues, tension may be relieved by undermining the margins of the wound for a certain distance with the scalpel (subcutaneous detachment). If this be not sufficient, two parallel incisions may be made, one on each side of the cleft.

2. THE METHOD BY GLIDING OR LATERAL DISPLACEMENT

Here the skin and subcutaneous tissues in the immediate vicinity of the defect or gap to be covered or closed are dissected

up, and the tongue or strip of skin is so drawn upon and displaced as to occupy the freshened surface of the part to be covered.

In this case also it must be remembered that all edges and surfaces which are to be brought into contact must be liberally freshened. The strips of skin made use of to close the gap must

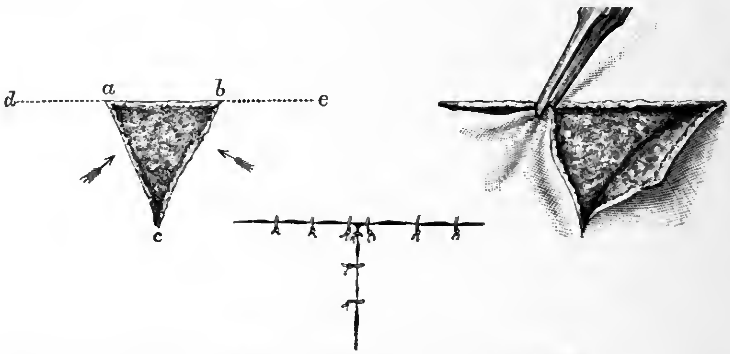

FIG. 232.—COVERING A LIMITED RAW SURFACE BY UNDERMINING AND LATERAL DISPLACEMENT.

be thick, and must include the subcutaneous tissues. The disposition of the strip must be influenced by convenience, by anatomical circumstances, and the arrangement of the blood-vessels. Bleeding should be checked before the sutures are drawn tight, and undue tension must not be allowed to fall upon the stitches.

A. **To close a Triangular Gap.**—(1) If the gap be small, and form an equilateral triangle, the area may be closed by uniting the sides or angles of the triangle.

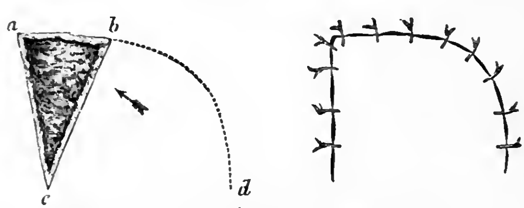

FIG. 233.—JAESCHE'S OPERATION. (*Löbker.*)

(2) If the defect be of larger size, one of the following methods may be made use of :—One side of the base of the triangle may be extended by an incision which continues the line of the base. The tongue of skin so marked out is freed by subcutaneous detachment, and the point of the freed flap is fixed to the angle on the undisturbed side of the base of the triangle.

(3) The tissues upon both sides of the triangle may be freed in like manner (Fig. 232), so as to bring the two flaps together, i.e. uniting the point *a* to the point *b*.

If necessary, the mobilisation of the tongues of integument

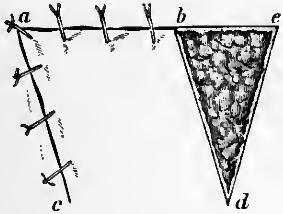

FIG. 234.—DIEFFENBACH'S OPERATION.

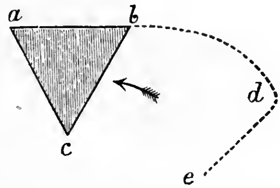

FIG. 235.—DIEFFENBACH'S AND JAESCHE'S METHODS COMBINED.

may be aided by lateral parallel incisions made beyond the points *d* and *e*.

(4) In order to conform with the natural line or disposition of the tissues or features, or to avoid nutrient vessels, a curved lateral incision (*b d*, Fig. 233) may be made, and the skin at *b* attached to the integument at *a*. Slight modifications of this

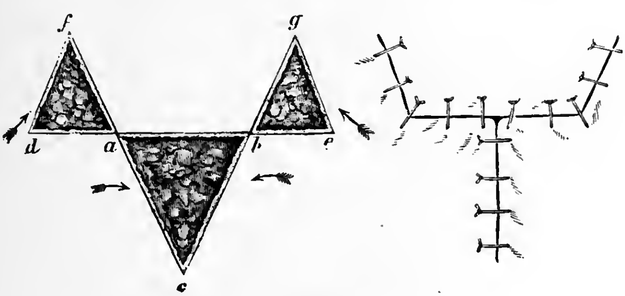

FIG. 236.—BUROW'S OPERATION.

method are shown in Figs. 234 and 236. They will be understood without any description.

(5) The methods of Dieffenbach and Jaesche may be combined, as is shown in Fig. 235.

B. **To close a Quadrilateral Gap.**—(1) Two parallel incisions in continuation with the longer margins of the wound are made on either side of the area to be covered in : *e a*, *f c*, *b g*, *d h* (Fig. 237). The two flaps, *e a f c*, *b g d h*, are detached, and are united

along the margins, *a c*, *b d*. In many cases the formation of one lateral flap is sufficient, or the mobilisation of the two strips of integument may be aided by parallel lateral incisions, made beyond the attached bases of the two flaps.

(2) Two lateral flaps, *a e f g*, *b h i k* (Fig. 238), are marked

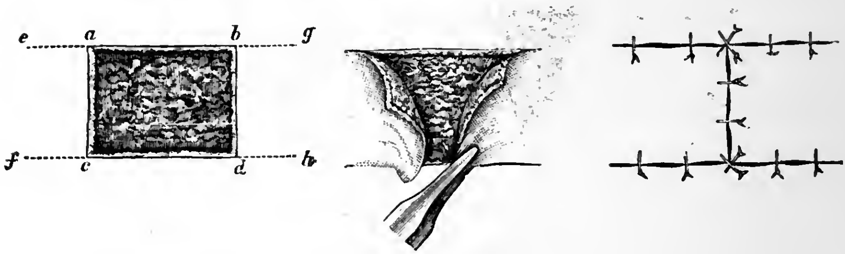

FIG. 237.—(*Löbker.*)

out and detached, and are so brought together that the borders *e f* and *h i* are united in the median line.

c. **To close Large Elliptical Defects.**—(1) Simple curved flaps, such as *a c d e*, *b c d f* (Fig. 239), may be cut and freed by subcutaneous detachment, and may then be displaced upwards, so as to close the raw area.

A slight modification is shown in Fig. 240. The two flaps *a c d* and *b e f* are made longer as well as narrower and more pointed.

The upper flap is made to cover in the whole original gap,

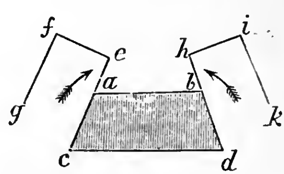

FIG. 238.—BRUNS' OPERATION.

the point *c* being raised to *b*. The lower flap is then drawn over to the left to cover in all or nearly all the raw surface left by moving up the flap *a c b*.

Comment on the Methods given above.—These methods, with such modification as occurs to the operator at the time,

are most useful in extensive operations for cancer of the lower lip, etc. It is obvious that most of them involve some stretching or folding of tissues—since those on one side of a linear incision are made to unite with others of a much greater length. The

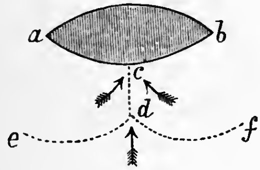

FIG. 239.—SIMPLE CURVED FLAP.

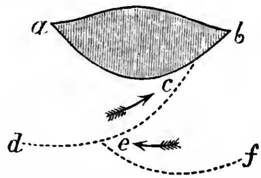

FIG. 240.—WEBER'S OPERATION.

immediate result therefore may not look so well in practice as the diagrams given would imply. But the tissues of the face adapt themselves to such changes and settle down in a remarkable manner, so that ultimately a smooth surface with inconspicuous scars is obtained.

3. THE METHOD BY FLAP FORMATION

Some of the methods just described may be properly considered as involving treatment by flap formation, and to be allied to what is known as the Indian operation; it is convenient, however, that the two sets of operations should be kept distinct.

The two chief methods of flap formation in plastic surgery are the Italian and the Indian.

(1) The **Italian or Tagliacotian method** involves the derivation of the flap from a distant part. In the restoration of the nose, for example, the flap may be obtained from the arm. The flap so employed is partially dissected up, and is left attached to the limb by its pedicle. It is in due course adjusted to its new situation, and after it has acquired a vascular connection with the tissues around the area it has to occupy, its connection with the arm is finally severed. This method is so difficult and so irksome to the patient that it is rarely performed now. It need not therefore be described.

(2) The **Indian method** is understood to involve the derivation of the flap from the neighbouring integuments. Thus, in repairing defects of the nose the flap may be obtained from the

forehead or cheek. A pedicle is formed, and the flap is drawn into its new position by torsion or gliding.

These operations are considered in detail in the section on Rhinoplasty (page 116).

A good example of this method is furnished by the following operation for ectropion, a condition frequently met with after the cure of lupus of the cheek, etc. The first step consists in cutting the eyelashes on both lids as short as possible. With a very fine knife the edge of each lid is then pared just within the line of the eyelashes so that the two lids may be sutured together. A curved incision is now made parallel with the edge of the everted lid, this incision is deepened and enlarged until the lid can be easily brought up to meet the upper one. Thus a wide gap is produced, and the two lids are sewn together with fine

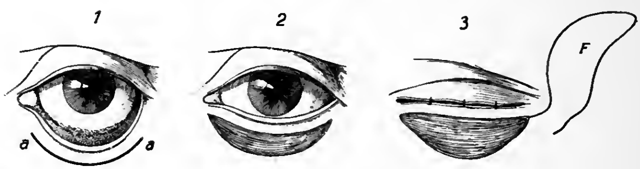

FIG. 241.—FLAP OPERATION FOR ECTROPION OF LOWER LID.

1, Curved incision made below edge of everted lid; 2, Incision opened out to full extent 3, Temporal flap F shaped out ready for suturing in the gap. The eyelids are fixed together by a few sutures.

silk introduced at three or four points along the lid-edges (Fig. 241). A flap is now shaped from the healthy skin of the temple, the apex of the flap being upwards and its pedicle joining the outer end of the raw surface already prepared (Fig. 241). The flap is made slightly longer and wider than the gap, as it is sure to contract somewhat. Its shape and borders must be made to correspond with those of the gap. After this flap has been carefully raised down to its narrow pedicle, all bleeding is stopped by forceps pressure, aided perhaps by fine ligatures. Finally the flap is swung round and laid in position, its apex is first united to the inner end of the gap, and its borders are sutured with the finest silk or silkworm gut.

The temporal wound is now closed entirely by sutures, and only a linear scar will be left by it. A light dressing and bandage is applied, to be changed daily.

During the whole operation care is taken not to irritate or injure the eye or conjunctiva, and sterile water is used in preference to any antiseptic solution.

The two lids are only separated at the end of a fortnight; during this time their union has kept the lower lid stretched in its normal position, and given time for the flap to unite well. This operation for ectropion has given excellent results in an extensive series of cases under our care, and we have found it superior to any other method, such as the $\bar{V}$ $\bar{Y}$ operation described in ophthalmic works. The latter operation has almost always to be repeated, and the ultimate result is usually inferior to that given by the transplanted temporal flap.

The one condition essential for it is healthy skin in the temporal region. Fortunately in cases of ectropion this is usually present.

3. **Other methods** of disposing of the flaps may here be mentioned. In the *reversed flap* the cuticular surface is directed inwards and its raw surface outwards.

In employing *superimposed* or *double flaps*, the outer, raw or exposed surface of a reversed flap is covered by a second flap, the epidermic surface of which is turned outwards.

Treatment of the Flap.—In dealing with nearly all the cases in which a flap is fashioned, one of two methods may be followed:—(*a*) The flap may be at once fixed with sutures in its new situation and to the newly-freshened surface prepared for it. (*b*) The implantation of the flap may be deferred for several days, until its vitality is fully assured and its surface is granulating. The raw surface of the flap is prevented from acquiring attachments during the preparatory stage by the introduction of a piece of carbolised oil-silk beneath it. The detachment of the flap and its final severance may by this means be considerably postponed.

The advantages of the latter method are these: The risks of sloughing of any part of the flap, and notably of its edges and free end, are greatly diminished. The flap is tested before it is employed. Instead of being transplanted just after it has been drained of blood and reduced in temperature, the flap is adjusted when it is vascular and the seat of an active repairing process. The treatment is certainly extended over a longer period of time, and involves greater inconvenience and possibly more pain to the patient, but these drawbacks are considered to be more than met by the security given by the delay. This method

has been carried out with great success by Thiersch in his operations for ectopia vesicæ (*Zentralbl. f. Chir.*, 1876, page 504).

The details of this method are considered more fully in the next section.

II. Operations for the Relief of Cicatricial Deformities after Burns

The grosser variety of deformity which results from the contraction of the integuments after severe burns has been the subject of a great number of methods of treatment. It must be confessed that the results obtained have not been proportionate to the ingenuity and patience expended upon the treatment.

The contractions with which this section is mainly concerned are situated in the neck, face, or upper extremity. Various methods of extension, by means of screw apparatus, india-rubber bands, weights, etc., have been tried, but with little success.

Much better results follow the methods now to be mentioned, both of them being commenced by a free division of the contracting bands. The latter consist always of scar replacing the skin and subcutaneous tissues, and hence the incisions need not be deep, but must extend widely enough to allow of full extension of the contracted joint. A large biconvex gap is thus produced, and is filled in at once either by (1) Thiersch skin-grafts, or (2) a flap shaped from comparatively healthy skin and subcutaneous tissue alongside of the cicatrix. Supposing that Thiersch grafts are used, it will be found that the best result is obtained by waiting a few days for healthy granulations to form and to rise to the level of the surrounding skin. It is tempting, of course, to finish the operation at once by transplanting the grafts at the time the incisions are made; but the former are not so likely to adhere to the fresh raw surface as to a smooth granulating surface, and if they do a puckered irregular scar will result. We have obtained the best results from fixing the part, after the incisions have been freely opened up, on a splint for some ten days or so. The wounds are meanwhile dressed with antiseptic gauze or boracic fomentations. At the second operation large grafts are taken from the arm or thigh and made to cover the granulating surface under oiled

silk which is perforated at many spots to allow any fluid to escape into the overlying dressing. Another method of grafting is given on page 116. Grafting is, however, unsuitable in certain regions such as the axilla, and even elsewhere the surgeon may prefer the second method, transplanting a flap from the neighbourhood of the scar. The flap is cut to correspond in shape and size with the raw surface, and is swung round on its pedicle into the gap, being secured by fine sutures at its margin. Thiersch grafts are then placed over the area left by moving the flap. Even pressure by an aseptic dressing and several days' rest of the part on a splint are required.

By means of two or more such operations a remarkable improvement can be effected in many cases of contraction after burns. The reader is referred to the description of a similar operation for ectropion on page 110.

If the flap required is a large and long one, it will be safest to follow the method introduced by Mr. Croft.

The account which follows is derived from Mr. Croft's paper in vol. lxxii. of the *Med.-Chir. Trans.* (1889).

Mr. Croft has illustrated his procedure by an account of five cases, in all of which the treatment may be considered to have been successful.

The method consists of raising a strip or bridge of sound skin, which is left attached by its two extremities, but which is separated through the rest of its extent from the subjacent tissues by means of oiled silk.

After the process of granulation has been well established, the contracted structures are divided, and the bridge of skin, having been severed at one extremity, is made to occupy the gap formed by such division. The operation is indeed a flap operation, in which the attachment of the flap in its new situation is deferred until granulation has occurred.

The Operation as carried out by Mr. Croft.—The strip or bridge of skin to be raised is cut where it can be taken free of scar tissue and well supplied with blood, yet sufficiently near to allow of its being twisted into its new bed. In the neck the bridge of skin may measure eight or nine inches in length. These bridges are cut as thick as possible, especially in their central parts (Fig. 242).

i

The bleeding from the flap and wound is carefully arrested before dressings are applied.

The sides of the wound are approximated by sutures, but tension from the stitches is avoided as much as possible.

With the object of promoting approximation or preventing retraction of the edges, these are sutured to the muscle and fascia near the centre of the gaping wound.

This fixation of the edges is of assistance in limiting the extent of surface which has to heal by granulation.

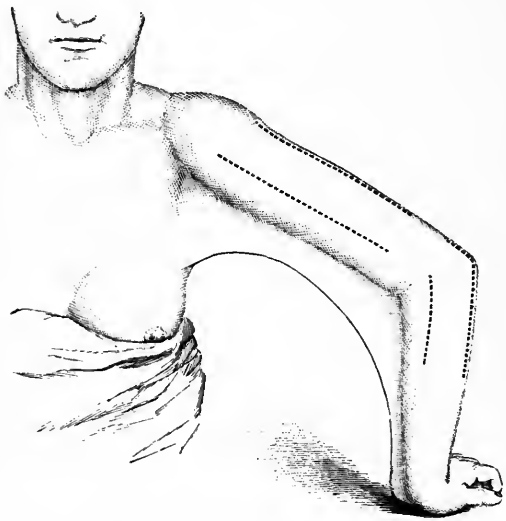

FIG. 242.—CROFT'S OPERATION FOR THE RELIEF OF CICATRICIAL DEFORMITY AFTER BURNS: POSITION OF BRIDGES OF SKIN IN A CASE OF BURN OF THE UPPER LIMB.

The strip or bridge is left attached at either end.

The under-surface and edges of the bridge are to become covered by granulations. Care must be taken to prevent it from re-uniting, and especially that granulations do not spring up in the angles formed between the pedicles and the raw surface. In this situation there is not a little risk that the length of the span may become insidiously shortened.

A layer of oiled-silk protective, well sterilised, is inserted between the raised skin and the parts beneath it, and is carefully drawn under the pedicles.

The whole operation area is covered with a light antiseptic dressing, and the part is so secured as to keep the entire region at rest. A rigid fixation apparatus may be required, especially in young patients.

If all goes well, and no complication occurs, in a fortnight or three weeks' time it will be safe to proceed to the next stage of

the operation—viz. that of cutting across the contracted scar and transplanting the strip of skin. In judging of the right moment for beginning the second stage, the surgeon must take into account the condition and extent of the granulating wound, the fresh loss of blood which must ensue in making a bed for the transplant, the extent of this fresh wound, and the influence that the operation will have upon the vitality of the transplant, which must now depend on one pedicle instead of on two.

At this second operation it is better first to cut through the contracted scar, and afterwards to cut across one end of the bridge. In dealing with the scar no tissue should be sacrificed. The scar tissue should be divided until healthy fat, fascia, or muscle is reached. All bleeding should have ceased before the final fixation of the transplant.

The bed and the flap must be made to agree in length, and for the most part in width, but the shape of the fresh wound cannot always be made to correspond exactly with the shape and extent of the transplant.

The form of the bridge will now have considerably changed from what it was when it was first cut. It will have become shorter and narrower and thicker.

The strip must be to a certain extent trimmed. The edges and granulating under-surface at the free end, for a distance of about half the length of the strip, should be pared or freshened, so that a raw surface is presented for primary union.

In none of Mr. Croft's cases did the transplant correspond in its uniform width to the width of the bed for it. The latter always varied, except at the part which was to receive the free half or third of the flap.

It is enough to obtain primary union between the free end of the flap and the fresh wound. This union anchors the strip and fixes it in its place.

Union along the rest of the extent of the transplant is only a work of time. At first the transplant looks very ungainly and unpromising. As week after week goes by and healing takes place, the sausage-like thing flattens down and spreads out, until finally it may become twice as wide as it was originally cut.

The part of the transplant which causes anxiety is the distal inch of it. This may slough to a slight extent, and union may

therefore fail to take place. In consequence of this the strip may retract from its holding. It must then be kept in place by the troublesome process of strapping.

After healing has taken place, the surgeon must wait for about six months before he can judge of the final result of his operation.

Grafts of the Whole Skin taken from a Distance (Wolfe's method).—Wolfe of Glasgow showed in 1875 that even large grafts of skin, including the cutis vera, might safely be transplanted without going through the laborious procedure in several stages which is described as Croft's method. Such grafts are naturally better fitted to supply an extensive gap than Thiersch's epidermic ones. The procedure which has been also advocated by Krause of Altona, R. Kennedy of Glasgow, and others is a simple one. Strict asepsis should be secured, the graft should be fixed in place by sutures, and it should be fully the size of or even rather larger than the gap which is to be filled up. The graft may be taken from any convenient part, such as the arm or thigh, the surface being previously rendered aseptic. It is carefully shaped with the scalpel, and any subcutaneous fat cut away from its under-surface. The finest silkworm-gut may be employed to fix it in position, and gentle pressure applied over it by means of a gauze dressing. The graft is at first quite destitute of vessel and of sensation, but it gradually assumes a healthy colour, and in the course of seven weeks or more recovers sensation. There is undoubtedly more tendency to shrink than when a pedunculated flap is moved laterally into the gap, but if due care is taken as to asepsis the whole graft usually survives. (Kennedy, *Brit. Med. Journ.*, April 29th, 1905.)

III. Rhinoplasty

A very large number of plastic operations, most of them ingenious and all more or less complex, have been designed to repair defects of the nose. The defect may be due to congenital deformity, or may depend upon injury, or upon the results of lupus, syphilis, or other destructive forms of ulceration. Any operation is contra-indicated in the case of partial or complete loss of the nose, the result of cancer.

The main flaps out of which the new organ is formed may be

derived from the forehead, the cheek, the arm, or forearm. It is seldom that the whole of the nose is destroyed, and it will be evident that the least successful results follow in cases in which the bony parts of the nose have been lost.

In *complete rhinoplastic operations* it is assumed that the whole of the cartilaginous part of the organ, including the tip, the columna, the alæ, and more or less of the septum, is lost.

Partial rhinoplasty concerns itself with slighter defects, and is employed to replace the tip of the nose, or one ala, or part of

FIGS. 243, 244.—KEEGAN'S METHOD OF PERFORMING RHINOPLASTY: PORTRAITS OF THE SAME PATIENT BEFORE AND AFTER OPERATION. (From the *Lancet*, Feb. 21st, 1891.)

the septum, or to close a fistulous opening in the skin of the member.

Many of these minor operations are very successful, but many of the procedures which aim at the restoration of the entire nose do not give brilliant results.

Among the most excellent results obtained by rhinoplasty must be placed the very admirable series of cases published by Surgeon-Major Keegan in the *Lancet* for Feb. 21st, 1891. (*See* Figs. 243, 244.)

In cases in which the bony framework of the nose has been lost, or in which the patient is the subject of a "depressed nose"—as in congenital syphilis—the results are almost entirely unsatisfactory. An unsightly gap in the face may be closed in the one case, it is true, but it will be covered in by a flap of skin

which is in time level with the cheek. In the case of the depressed nose it is a question whether the " improvement " merits that term, and to replace a flat area of integument by a rudimentary and imperfect ridge is to effect a change in the features of doubtful advantage. It is probable that better results may follow the injection—at a later period—of paraffin under the new flap of skin.

Even in cases in which the nasal bones have survived, the results have often little to commend them. The new nose may be large and bulbous, or puny and abortive, and a feature which is unsightly may be replaced by one which is simply ridiculous. In the operations which involve the formation of a flap from the tissues of the face much additional disfigurement may result from an unsightly scar on the forehead or the cheek. The results, however, obtained since improved methods of treating wounds have been introduced are certainly more encouraging.

It is true that the tissues of the face are admirably adapted for plastic procedures, and the actual surgical results, so far as healing is concerned, are often all that could be wished.

Before proposing a complete rhinoplastic operation, the use of an artificial nose carefully fashioned and coloured should be considered. Within the last few years remarkable improvements have been effected in the manufacture of these artificial features. Though even the best look unnatural, they are at least symmetrical and well-shaped, and do not look ridiculous.

By means of a spectacle-frame an attachment of the upper part of the new member can be obtained, and in adult males a false moustache may be made to secure the lower attachment.

The special elements of failure in rhinoplastic operations are gangrene or sloughing of the flap, imperfect healing, secondary hæmorrhage, shrinking, or persistent œdema or distortion, of the attached flap, and, lastly, a recurrence of the original disease.

COMPLETE RHINOPLASTY

A selection from the extremely numerous operations embraced by this title will be considered under the following headings :—

1. The Indian operation (flap taken from the forehead).
2. The French operation (flap taken from the cheek).
3. Other operations.

1. **The Indian Operation.**—This procedure, as modified by modern surgeons, may claim to be at present the best rhinoplastic operation. The flap is derived from the forehead, and is brought into place by torsion. One great objection to this procedure is that a large and unsightly scar is left on the forehead. The operation, needless to say, is not applicable to cases in which the tissues of the forehead are unsound or are the seat of cicatrices.

First Stage.—The edges of the defect must be well and evenly freshened. The best results follow when the gap is triangular in outline, and in any case the outline of the area to be covered in should be made as nearly as possible triangular, the base of the triangle being towards the upper lip.

Second Stage.—When possible, a small thin flap should be formed from the skin of the root of the nose. This flap should be quadrilateral, with the base or attached side downwards. It should be detached and turned downwards (*a*, Fig. 245), so that its raw surface is directed forwards.

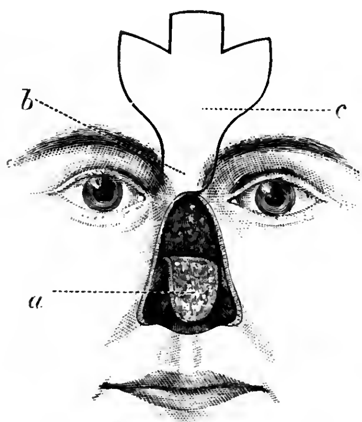

FIG. 245.—RHINOPLASTY.
a, Nasal flap ; *b*, Pedicle of frontal flap ; *c*, Frontal flap.

This flap can only be used when the skin over the nasal bones is sound and healthy. It serves to increase the solidity of the new nose, and to form a further attachment for the frontal flap.

Third Stage.—The frontal flap is made. A model of the new organ should have been already fashioned in thin gutta-percha or plaster. This model when flattened out is laid upon the forehead, and, guided by its outline, the flap is marked out. The flap should be about a third larger than the area of the defect, or in marking it out in ink upon the forehead a quarter of an inch may be allowed on each side of the prepared model. Enough tissue must be provided to allow for the alæ and columna. The upper extremity of the flap will reach about to the border of

the scalp. If the forehead be low the flap will encroach upon the hair.

The apex or narrow part of the flap will be, of course, at the root of the nose. The flap should include all the tissues down to the pericranium, which must not be disturbed. It must be dissected up boldly and freely.

The formation of the pedicle or apex of the flap is important.

It is well that the incision marking one side of the flap should be continued downwards into the recently freshened area (*b*, Fig. 245).

By means of this incision the pedicle can be lifted from the bones, and will contain the supratrochlear artery of one side. It is impossible that the pedicle can be so made as to include the arteries of the two sides; and if the plan just described be adopted, the compression of the artery by the torsion of the pedicle is reduced to a minimum.

The side selected for the pedicle must, of course, depend upon circumstances. Its width will be from 1 to 1½ cm. The incision marking the other side of the pedicle will end at the inner side of the eyebrow, as shown in Fig. 245.

The flap is usually placed in or about the median line. Some surgeons, and notably Dr. Keegan, direct the long axis of the flap obliquely, so that its tissues are derived mainly from one side of the forehead only. By this means it is considered that the risk of compressing the artery of the pedicle by torsion is minimised. The placing of the flap so obliquely that its long axis is nearly parallel with the eyebrow is, however, to be condemned.

The including of the pericranium in the flap, under the impression that it would produce bone in the new situation, is a perfectly valueless proceeding, and may lead to some exfoliation of the frontal bone. The indisposition of the pericranium to form new bone is well known.

All bleeding must be arrested by sponge pressure or pressure forceps. No ligatures should be employed.

The shape of the flap may now be considered.

The outlines here described are those of (*a*) the triangular flap, (*b*) the pyriform flap of Dieffenbach, (*c*) Langenbeck's flap, and (*d*) Keegan's flap

(*a*) The triangular flap conforms to the original plan of the operation, and is the basis of the many modifications. Its outline is shown in Fig. 246, which represents the full size for an adult. The line *d d* indicates the median line of the dorsum of the new nose. The upper border of the flap is divided into three parts by the two vertical incisions *a c*, *a c*. The median part is utilised to form the columna, and the two lateral parts to form the alæ. The length of the central part must depend upon the profile of the features.

The lateral flaps are bent backwards along the lines *a b*, *a b*, so as to conform to the outline of the alar part of the nose. A narrow wedge-shaped piece of skin will probably have to be excised along the lines *a c*, *a c*.

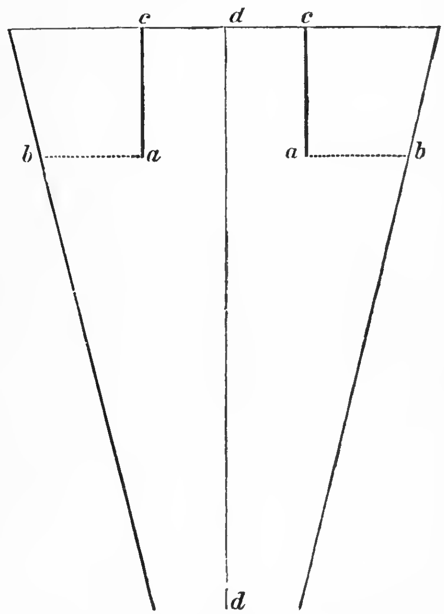

FIG. 246.—RHINOPLASTY: THE TRIANGULAR FLAP. (Natural size.)

(*b*) The pyriform flap of Dieffenbach is formed upon the same plan as the above, its proportions are estimated in the same way, and the pedicle is arranged in the same manner. The outline of the flap is shown, of natural size, in Fig. 247. The incisions *a c*, *a c* are made as before, in order to mark off a central segment for the columna. The lateral flaps are bent back in the direction of *c′ c′*, and are utilised to form the alæ.

(*c*) Langenbeck's flap has the outline shown in Fig. 248 (natural size). In its general proportions and in the disposition of its pedicle it follows the rules already laid down. The central segment *a c*, *c a* forms the columna, the lateral segments—which are bent backwards along the lines *a b*, *a b*—the alæ. This flap is in many respects the best of those described.

(*d*) Keegan's flap is described on page 125.

Fourth Stage.—The frontal wound is closed as far as is possible. If the triangular flap be used, the raw area can be closed in to a considerable extent. In Dieffenbach's flap the area can be but little diminished, while the most complete diminution of the raw gap can be effected when Langenbeck's or Keegan's method has been employed.

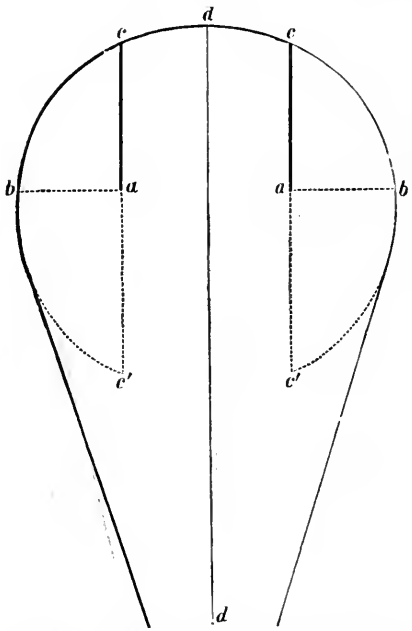

FIG. 247.—RHINOPLASTY: DIEFFENBACH'S FLAP. (Natural size.)

Fine hare-lip pins and silkworm-gut sutures may be used for this part of the operation.

At a late period Thiersch's method of skin-grafting may be employed.

By dealing with the frontal wound at this stage the bleeding is considerably diminished, and the surgeon has a clearer field for the manipulation of the flap.

Fifth Stage.—The flap is fixed into its new position. It is carefully twisted, and during this step the surgeon must hold in mind the possibility of occluding the nutrient artery by torsion.

The flap is secured in place by interrupted sutures of silkworm gut. These must not be too closely inserted, and no traction must be made upon them. The lateral parts of the flap are secured first, then the columna, and lastly the alæ.

If the columna has been provided for in the frontal flap as above described, then a suitable groove must be cut in the median part of the upper lip to receive it. If no columna can be obtained from the tissues of the forehead, then it must be formed from the upper lip (page 123), either at once or at a later period.

If no columna be fashioned at this stage, the flap must be carefully supported by a light plug of gauze, which should

be changed frequently. If the septum of the nostrils be restored, then each of the new nostrils must be supported with pieces of drainage-tube of suitable size. These must be retained in position for some weeks.

A simple dry antiseptic dressing is applied, which is secured in place by a light gauze bandage.

The after-treatment is conducted upon general principles. Portions of redundant flap may have to be excised, or some slight secondary operations undertaken to improve the appearance of the new organ.

The pedicle may be severed at the end of three to four weeks, and the wrinkled portion of protuberant skin which marks its position is excised in the form of a wedge-shaped piece, to prevent the formation of a parrot-shaped nose.

Extensive skin-grafting will be required for the granulating surface on the forehead.

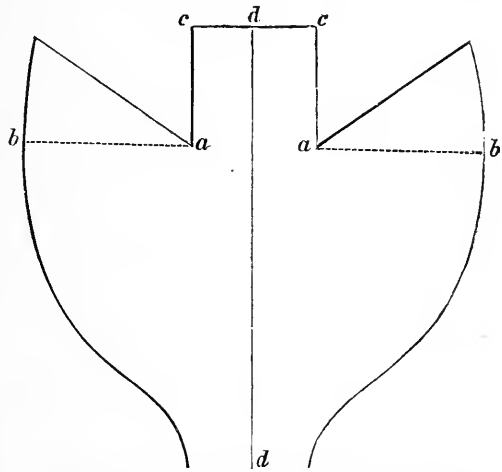

FIG. 248.—RHINOPLASTY: LANGENBECK'S FLAP. (Natural size.)

Modifications of the Operation. — (1) *The frontal flap may be partially detached at first,* and may have its upper attachment severed after its raw surface is granulating, and be then twisted into its new situation.

This modification has been briefly described (page 114).

Although this plan is admirably suited for some plastic operations, notably for such as are concerned with the relief of deformities produced by burns, it does not appear to be well adapted for this form of rhinoplasty, and it is to be noted that nearly every surgeon who has advocated the Indian method has carried out the immediate adjustment of the flap.

(2) *The Formation of a New Columna from the Lip.*—In the description given above, provision for the new columna is made in

fashioning the frontal flap. If, as is often the case, especially in patients with low foreheads, it is not possible to form the new septum from the frontal tissues, the columna may be taken from the lip.

A narrow vertical strip (*b c*, *b c*, Fig. 255) of the median part of the upper lip is isolated by means of the scalpel.

This strip will be about one-fourth of an inch in width, will be quadrilateral, will be equal in length to the depth of the lip, and will include at its free end a part of the red margin of the lip. The little flap will be entirely free, except at its upper or nasal extremity, and to ensure its freedom the frænum of the lip, and the reflections of the mucous membrane from the lip to the maxilla, must be severed.

During the cutting of this thick but narrow strip of tissue the coronary arteries should be compressed by an assistant.

In males it is well to dissect off the skin, and with it the hair follicles.

The tip of the little flap is freshened, and is drawn forwards and fixed *in situ* to the tip of the nose.

It will be seen that the cutaneous surface of the flap forming the new columna is turned upwards, i.e. looks towards the nasal fossæ, while the mucous surface is directed downwards, i.e. looks towards the chin. The flap is merely bent upwards, and is exposed to no torsion. The mucous membrane in time becomes thickened, and resembles skin.

After the columna has been fixed in position the gap in the upper lip is closed with sutures.

Volkmann, Bennett of Dublin, and others, are opposed to the formation of a special columna. They point out that the contraction of the deep surface of the frontal flap leaves an orifice none too large for the admission of air. The flap is allowed to hang freely downwards, and its extremity is not secured by sutures. The contraction of the flap leads to the formation of a definite tip to the new nose, the appearance of which, it is claimed, would not be improved by a columna.

(3) *Operations to prevent depression of the new nose* have led to numerous ingenious experiments and to many modifications of the original operation.

Supporting plugs of amber or of gold have been employed, and various "nasal levers" have been devised, but the retention of these foreign bodies has caused intolerable irritation and ulceration.

The late Mr. William Anderson, however, succeeded in forming a support by bent silver wire fixed into the remains of the septum and the superior maxilla. In two cases this wire support was retained without irritation.

Thiersch made two small longitudinal skin flaps from the edges of the gap to be closed, and, turning them both inwards, united them in the median line. The integumentary surfaces of the little flaps were thus turned inwards, the raw surfaces outwards. Upon this raw surface the frontal flap was allowed to rest, and from this small under-flap it obtained support.

Langenbeck cut, with a fine saw, lateral pieces of bone from the osseous margins of the nasal aperture. These, when sufficiently separated, were lifted up with an elevator, and were so placed with

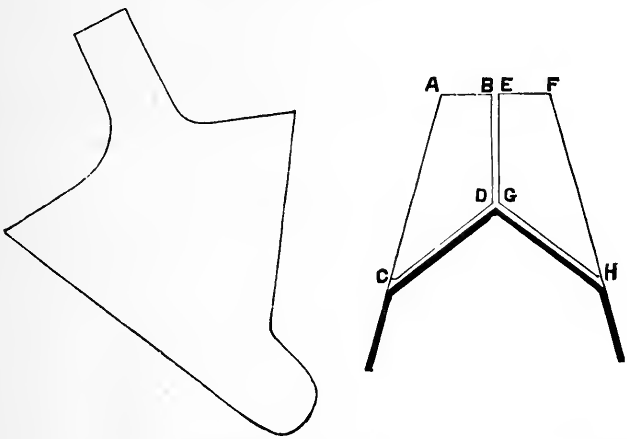

FIG. 249.—RHINOPLASTY. KEEGAN'S OPERATION: THE FLAP IS REDUCED IN SIZE. (From the *Lancet*, Feb. 21st, 1891.)

reference to one another that they acted like the beams of a roof to support the alæ and apex of the new nose.

Recent experience points to the probability that an efficient support may be provided by paraffin.

(4) *Keegan's Operation.*—This method of rhinoplasty is thus described by Surgeon-Major Keegan in the *Lancet* for Feb. 21st, 1891:—

The operation is begun by carrying two converging incisions (C A, H F, Fig. 249) from two points slightly external to the roots of the alæ nasi to two points about three-quarters of an inch apart on the bridge of the nose, where a pair of spectacles would rest. These two points on the bridge of the nose are now joined by a horizontal incision, A F. This horizontal incision is bisected, and a perpendicular incision (B D, E G) is drawn downwards from the point of bisection nearly as far as where the nasal bones join on to the cartilage of the

nose. In other words, this perpendicular incision follows the course of the junction of the nasal bones, but is not carried down as far as their inferior borders. The skin and tissues are now dissected cautiously from off the nasal bones from above downwards in two flaps, A B C D and E F G H, as in Fig. 249.

The two inferior borders of the flaps—viz. C D and G H—are not interfered with, and constitute the attachment of the flaps to the structures and tissues which clothe the inferior borders of the nasal bones, where they join on to the cartilage of the nose. If these two flaps are reflected downwards, so that their raw surfaces look forwards and their cuticular surfaces look backwards, it will be found that they overlap in the centre. The surgeon has therefore a redundancy of flap to deal with, a redundancy which he can utilise a little later when he has raised the flap from the forehead. He now proceeds to do so in the usual way. The root of the pedicle occupies the internal angle of the eye. The flap is inclined obliquely, and its outline is shown in Fig. 249. The pericranium is not disturbed. The sides of the gap now left in the forehead are approximated as quickly as possible by means of horsehair sutures, and it is surprising how small a raw surface is left behind on the forehead if the approximation of the sides of the gap be judiciously and expeditiously carried out. Attention is now directed to preparing a nidus or bed for the reception of the columna, and this does not require any description. The two flaps, A B C D and E F G H, which have been already raised from off the nasal bones, are now reflected downwards, and, as they overlap in the centre, two triangular-shaped pieces are cut away and placed in the middle of the gap left in the forehead, in order to expedite the process of cicatrisation in the frontal scar. The forehead flap is now brought down over the nasal bones, and rests inferiorly on the two reflected flaps, A B C D and E F G H, taken from off the nasal bones. The raw surface of the frontal flap, inferiorly, lies on the raw surfaces of the two reflected nasal flaps, and the nostrils of the newly-formed nose are therefore lined inside with the skin or cuticular sides of the reflected nasal flaps. The free inferior margins of the forehead flap and the nasal flaps are now brought together by horsehair sutures. The columnar portion of the forehead flap is now fixed by sutures in the bed prepared for it, and the two original incisions drawn from the root of the alæ nasi on either side to the bridge of the nose are now deepened and bevelled off for the reception of the sides or lateral margins of the forehead flap. The sides or lateral margins of the forehead flap are most accurately attached by means of horsehair sutures to the bed prepared for them. Two pieces of drainage-tubing are

inserted in the newly-formed nostrils. Strips of lint on which some boracic ointment has been smeared are placed over the junction of the lateral margins of the new nose to the cheeks, and also on the gap left behind on the forehead, and cotton-wool is applied over all.

Dr. Keegan divides the pedicle of the new nose at the end of a fortnight. The drainage-tubes which occupy the new nostrils are removed after ten days.

Dr. Keegan's paper is illustrated by a number of portraits of patients before and after operation, and the results obtained are in every respect most admirable.

2. **The French Operation.**—In this procedure rhinoplasty is performed by the transposition of lateral or facial flaps. The method is of great antiquity, and was described by Celsus.

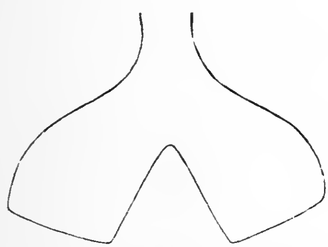

FIG. 250.—SYME'S METHOD OF RHINOPLASTY: THE FLAP FROM THE CHEEK.

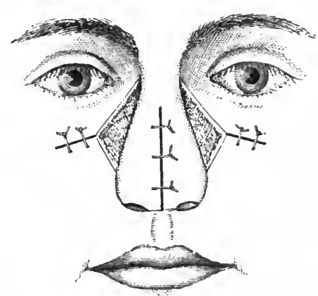

FIG. 251.—SYME'S METHOD OF RHINOPLASTY: THE FLAPS IN POSITION.

The operation is considered to be best suited for cases in which the upper part of the nose remains intact.

The frontal scar is avoided, but the tissues of the cheek are found by experience to be but ill adapted to the formation of a substantial flap which will not undergo exceptional shrinking.

The new nose is apt to be quite flat, and its vascular supply is feeble, since the arteries of the flap which are derived from the facial are cut in the operation.

Hæmorrhage is very free during the cutting of the flaps.

A cicatrix of a somewhat prominent character is left upon the cheek of either side, and a scar marks the median line of the new nose.

(A) *Syme's Operation.*—A large symmetrical flap of the shape shown in Fig. 250 is marked out on the cheeks. Its size is regulated by the rules already given (page 119), and by the dimensions required

for the new organ. The pedicle of the flap is median, and is placed above at the root of the nose and between the two inner canthi.

The area to be covered having been freshened, the bilobar flap is freely dissected up, and when all bleeding has been checked the two lobes of it are united in the median line, while its outer margins are sutured on either side to the raw surface at a proper distance from the nasal orifice.

The edges of the wounds left in the cheeks must be brought together, as far as is possible, by sutures, the triangular gap which will remain on each side close to the new nose being left to close by granulation aided by skin-grafting (Fig. 251).

The contraction produced by the healing of these triangular gaps often enhances the apparent height and prominence of the new organ. The nostrils of the new nose must be supported for a time by a plug of gauze or by short pieces of drainage-tube.

Mr. Bell advises that if any part of the old septum remain, it may be made use of as a fixed point. A straight needle is thrust through one lobe of the flap close to its outer lower edge, is then passed through the septum, and is finally brought out at a corresponding point on the other lobe of the flap.

(B) *Nélaton's Operation.*—This surgeon marked out two thick trapezoidal flaps from the cheeks.

Each flap is intended to form the corresponding half of the new nose. The pedicles of the flaps are situated above, near the lachrymal sac, while their bases are below. Each flap contains all the soft parts down to the bone, including the periosteum, which is stripped off the exposed portions of the ascending parts of the superior maxilla on either side.

The flaps are sutured together along the median line, and are attached also by their outer margins as in Syme's procedure.

The sides of the nose are supported and kept in contact by a hare-lip pin, which is passed through both alæ, while the parts transfixed are compressed by means of a pince-nez, which is steadied by the steel pin.

The results of these operations have not been very satisfactory.

3. **Other Operations.**—*Operations for Depressed Nose.*—In these instances the nose is perfectly flat. The integuments are probably sound, and no actual gap or defect marks the surface. The bones and cartilages, however, which support the organ are wanting to a greater or a lesser degree, and the resulting deformity is considerable.

Operative interference in this class of case has been attended with most unsatisfactory and invariably disappointing results.

A simple method recently introduced has given fairly good results. It consists of injecting melted paraffin into the tissues beneath the depression. The paraffin sets, and more or less effectually restores the contour of the nose.

In some examples one of the above complete operations for the formation of a new nose has been carried out. In such instances the scanty tissues of the depressed nose have been made use of to form secondary flaps. The operative measures alluded to in the section on operation to prevent depression of the new nose (page 124) have been applied in these instances. In Verneuil's method, described below, the use of nasal flaps, aided by a much-modified frontal flap, is the conspicuous element in the operation.

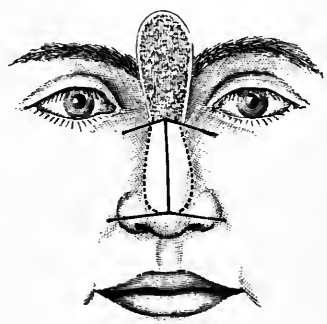

FIG. 252.—VERNEUIL'S METHOD OF RHINOPLASTY: THE FLAPS IN POSITION.

It is at present a matter of question whether in these instances a better result cannot be obtained by the subcutaneous injection of paraffin or by the adjustment of an artificial nose. As the operations in vogue cannot be considered to have been as yet entirely put aside in favour of non-operative measures, the best-known of them is here described.

It is assumed that the tip and alæ of the nose are not wanting.

Verneuil's Operation.—An incision is made vertically along the median line of the depressed organ.

At each end of this—i.e. at the root of the nose and just above the alæ—a transverse cut is made. The two nasal flaps thus marked out (Fig. 252) are dissected up. A comparatively small oblong flap is now raised from the middle of the forehead, its pedicle being placed between the two inner canthi.

It is turned downwards—without torsion of the pedicle—so that it closes the large opening made into the nasal fossæ by the dissection of the nasal flaps. The raw surface is anterior or external, the cutaneous surface looks towards the nasal fossæ.

This flap is fixed in position by a few sutures.

The two nasal or lateral flaps are now drawn over it, and are united together in the median line. The wound in the forehead is closed as far as possible by means of sutures and a hare-lip pin, and the granulating surface left is subsequently grafted. The pedicle of the frontal flap will, at a later period, require to be divided and trimmed.

j

In Verneuil's case the new nose thus formed was raised one-third of an inch above the adjoining surface. The scars formed by the lateral incisions fade gradually into the naso-labial sulci and the folds beneath the eye.

Mr. Jacobson speaks well of this operation.

Operation for Depression of the Nose due to Displacement of the Cartilages from the Nasal Bones.—This condition will be the result of a well localised injury in which the nose has been "smashed in."

In these cases Mr. Walsham (*Lancet*, April 4th, 1903) claims to have obtained the happiest results by wiring the cartilages to the bones. An incision is made exactly in the centre of the nose in a vertical direction, beginning about half an inch above the ends of the bones and continued for half an inch or more over the cartilages. The sides of the skin incision are carefully dissected up from the bones and cartilages for a good half-inch on each side. With a sharp knife the cartilages are next divided transversely along the line of the osteo-cartilaginous junction, avoiding perforation of the mucous membrane. If the cartilages can now be brought up to the level of the bones, well and good ; if not, the projecting ends of the bones may be snipped off with fine bone-scissors. The end of each bone is now perforated with a small bone-drill, and a fine silver-wire suture is passed through the hole thus made, with a curved needle, which is then made to perforate the corresponding cartilage from within outwards. On twisting the loop the cartilage will be drawn up into place. The opposite side is now treated in the same way, the ends of the wire are securely beaten down, and the external wound is closed with the finest fishing-gut sutures and sealed with a collodion gauze dressing.

PARTIAL RHINOPLASTY

The operations carried out for the relief of slighter deformities and partial defects of the nose are very numerous, and for the most part consist simply in the application of the common principles of plastic surgery to the part.

1. **Fistulous openings** of small size, leading into the nasal cavities, may be closed by freshening the edges, by freeing the tissues of the margins, and approximating them by sutures.

Larger openings may be closed by one or other of the methods already described for dealing with defects of various sizes and shapes (pages 106 *et seq.*).

2. **Defects in the central part of the nose**—the root and lower third being quite sound—may be remedied by the gliding method

(page 105), or by means of definite lateral flaps derived from the tissues of the cheek.

3. **The formation of a new ala** may be accomplished in many ways.

(A) *From the Nasal Tissues of the Same Side* (Denonvillier's Operation).—A pedunculated triangular flap is cut from the sound tissues of the nose, just above the defective ala. The pedicle is placed internally at the tip (Fig. 253).

The incision is commenced near the tip on the sound side (*a*), and passes upwards (*a b*) nearly to the root of the nose. From the end of this a second cut (*b c*) descends obliquely to terminate at the upper and outer angle of the defect (*c*). This flap is dissected up, and its lower part should contain a strip of undestroyed cartilage. It is finally displaced downwards, and fixed in position by sutures —the margins of the defect having been already freshened to receive it.

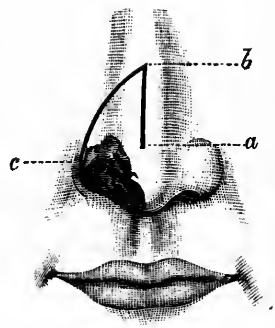

FIG. 253.—DENONVILLIER'S OPERATION.

(B) *From the Ala of the Opposite Side* (Langenbeck's Operation).—The most convenient shape to give the defect is a quadrilateral one. From the upper and inner angle of the defect an incision (*a b*, Fig. 254) is carried downwards along the dorsum of the nose, nearly to the apex on the sound side. A second incision (*c d*) is made, parallel to the first, and runs from just below the inner canthus to the junction of the ala with the cheek. The lower ends of the two incisions are united by a third cut (*b d*), which runs just along the free border of the ala. The quadrilateral flap thus marked out is detached from the cartilage as far up as the line of its base (*a c*). It is then drawn over to the other side, and is fixed by sutures to the freshened margins of the defective area. It will be noted that a triangular piece of sound skin is left at the tip of the nose. The defect left upon the sound side should be closed as far as possible, and should later on be grafted to prevent the contraction which would otherwise be inevitable.

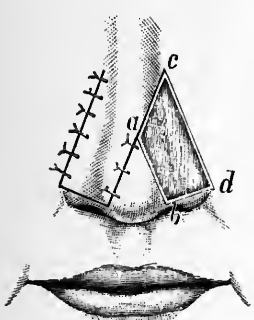

FIG. 254.—LANGENBECK'S PARTIAL RHINOPLASTY.

(C) *From the Upper Lip* (Weber's Operation).—The margins of the defective ala having been freshened, an oval flap is cut from the centre of the lip. The pedicle of this flap is attached alone to the columna, while its free margin reaches to the prolabium. Only a part of the thickness of the lip is concerned in the flap.

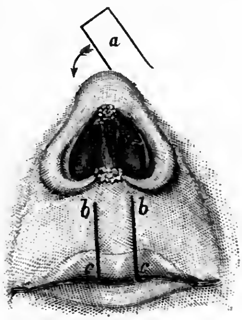

FIG. 255.—FORMATION OF A NEW COLUMNA.

b, *c*, From the lip; *a*, From the nose. Hueter's operation. (*Löbker*.)

It is turned upwards, and fixed into position by sutures. At the end of three or four weeks the pedicle is divided, and is applied to the inner surface of the flap, so as to give a thicker and rounder margin to the new ala.

4. **The formation of a new columna** is frequently called for.

(A) The columna may be formed from the tissue of the upper lip, in the manner already described (page 123).

(B) It may be derived from the dorsum of the nose—Hueter's operation. A quadrilateral flap (*a*, Fig. 255) is taken from the dorsum. The pedicle of the flap is placed near to the tip of the nose, and its free border not far from one inner canthus. The periosteum of the nasal bone is detached with the flap.

The flap is transplanted by twisting the pedicle.

IV. Operations for Hare-lip

The Best Time for Operation.—Very different, and to some extent quite irreconcilable, opinions have been expressed upon this matter. The principal point of dispute has been concerned with very early operations—operations undertaken during the first few weeks, or even the first few days, of life.

The weight of evidence and of opinion is, we think, now decidedly opposed to these early operations, and emphatically opposed to operations undertaken within a few hours or days of birth.

The best period for dealing with a hare-lip would appear to be between the third and the sixth month.

The late Sir W. Fergusson, from an experience of 300 to 400 cases, advocated a somewhat earlier date, "from three weeks to three months." Where a cleft palate coexists with hare-lip,

Mr. Arbuthnot Lane, in opposition to most surgeons, advocates that the palate should be dealt with first.

It is well that the defect should be dealt with before dentition commences. The first tooth to protrude (the lower central incisor) makes its appearance about the seventh month; the upper incisors are not usually "cut" until the eighth month.

It is desirable, therefore, that the deformity should be dealt with before the seventh month.

Against quite early operations, such as are undertaken during the first or second month of life, the following objections may be urged:—

1. The vitality of the very young infant is low, and the mortality of the first two months of life is remarkably high. During the first four weeks after birth the death-rate is 571·32 per 1,000; during the next four weeks it is 218·37 per 1,000; between two and three months of age it has fallen to 157·10; and at the age of six months the death-rate is represented by 115·09 per 1,000 (Registrar-General's Thirty-eighth Report).

2. In the very young infant the parts are small and fragile, are difficult to handle, and are more readily damaged. The tissues, moreover, afford a less firm hold for sutures.

3. The difficulty of feeding is quite unfounded and, such as it is, is soon got over with care and attention, and the risk of malnutrition and wasting, which is stated by some to attend hare-lip, has not been shown to offer a valid reason for early operation. The child who has become wasted has probably been indifferently cared for, or is the subject of some intercurrent disease, and a hasty closure of a cleft in the lip can hardly be expected to remedy the one or to remove the other. The argument that the child has wasted is an argument for postponing rather than for hastening the operation. The marasmic infant is a wretched subject for plastic surgery. If the palate be sound, many children with even severe hare-lip can suck admirably.

In order to ensure the success of the operation, the child should be in good health and its digestive functions in perfect order. It would be calamitous to discover, after the operation, that the infant was the subject of a cough or of severe coryza.

Another element necessary to success is a good nurse.

SINGLE HARE-LIP—THE USUAL OPERATION

The form of the hare-lip will determine the details of the operation or the method selected. There may be merely a notch in the lip, or the cleft may extend into the nostril, or may end just short of it.

In the most favourable cases the edges of the cleft are equal, are of substantial thickness, and are not widely separated. The majority of the examples of hare-lip may, perhaps, be placed in this category.

In less favourable instances the margins of the split are unequal and widely divergent, and it may be that the tissues of the lip are scanty and adherent. Owing to the septum being turned over to one side, the ala of the nose of the opposite side may be flattened, and the nostril represented by a mere transverse slit.

The complication of cleft palate may exist, and abnormally projecting premaxillæ may require to be specially dealt with.

Instruments required.—A fine, narrow, sharp-pointed scalpel or a small tenotome (for the less simple methods a slender double-edged knife is useful); slender-bladed dissecting forceps with toothed points; small sharp-pointed scissors curved on the flat; straight blunt-pointed scissors; artery forceps; sequestrum forceps with broad ends protected by indiarubber; needles and sutures; needle-holder; a gag and tongue forceps may occasionally be useful; small fine sponges.

The Operation.—The operation here described is that most usually carried out in Great Britain, and is the method adapted to the majority of the cases of single hare-lip.

The infant is wrapped up in a towel or sheet, so that the head alone projects. In this mummy-like guise it is easily handled, and the movements of its limbs are restrained.

The patient lies supine, with the head well raised and supported upon a sand-bag or firm cushion.

The surgeon faces the patient, or stands to the right-hand side. An assistant places himself behind the child, and steadies the head, while at the same time he compresses the facial arteries against the lower jaw. The administrator of chloroform will stand upon the left of the table.

First Step.—Grasping the upper lip, the surgeon proceeds to separate it—upon each side of the gap—from the maxilla. This can best be effected by means of small sharp-pointed scissors curved on the flat. The scissors must be kept close to the bone. It may be necessary to detach one ala of the nose from the maxilla. In any case the detachment should be sufficiently free to allow of the margins of the cleft coming together readily and without the least tension.

If the maxilla of one side project inconveniently beyond its fellow, it should be forcibly bent back with sequestrum forceps, the blades of which are protected by indiarubber. "The bone," writes Mr. Jacobson, "should be felt to crack when this is done, otherwise, if merely bent back, it springs forward again, and causes tension of the flaps."

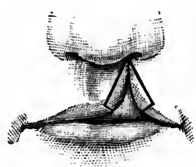

FIG. 256.—OPERATION FOR SINGLE HARE-LIP.

Second Step.—The edges of the cleft are pared. The lower angle of one flap of the lip is seized with fine-toothed dissecting forceps, is drawn upon, and the margin is then pared with the narrow scalpel. The incision for paring the edge should commence above, at the upper angle of the gap, and descending obliquely, should curve inwards, when the red margin or lower angle of the flap is nearly reached (Fig. 256).

When one side has been treated, the other is taken in hand.

Or the lip on one side having been made tense, it may be transfixed in its whole thickness from before backwards by the narrow scalpel. The point is entered just above the lower angle of the flap, and, the edge being directed upwards, the knife is made to cut towards the upper angle of the gap, to follow that angle, and finally to descend upon the other side. The knife is then withdrawn, and is not allowed to cut its way out. The piece isolated by paring will still be attached to the lip at both ends, and its detachment may be left until some of the sutures have been introduced, and until the amount of tissue required for the formation of a good free margin to the new lip has been ascertained.

In any case the paring must be freely, liberally, and evenly

carried out. The raw surface should be as wide as possible, especially below.

During this step there may be much bleeding, which must be checked either by pressure upon the facial arteries, or by the compression of each coronary artery at the angle of the mouth between the thumb and finger of an assistant. The latter procedure is the more efficacious, but the operation area is encroached upon and disturbed, and in the place of an assistant's fingers some form of hare-lip compression forceps may be used.

Third Step.—The gap is now closed. The assistant who holds the head presses the cheeks together with his fingers, so that the two raw surfaces are approximated. The approximation must be exact. The margins are then united by means of fine silkworm-gut sutures.

The first suture should involve the middle of the lip, the next the lower portion, and the third the segment near the nostril. These are the three main sutures. They should include the whole thickness of the lip, excluding the mucous membrane only; and the first or median suture, if properly introduced, should command the coronary arteries when it is finally drawn tight.

After the surgeon is satisfied that the best possible adjustment has been obtained, the sutures are tied in the usual way and cut moderately short.

The three stitches are introduced about one-third of an inch from each side of the cleft.

Two, three, or more sutures are now inserted at the free margin of the new lip, especially upon its inner or alveolar aspect. These are composed of the finest silk, and are passed by means of slender curved needles held in a needle-holder.

Some of these fine stitches may be required along the main wound, and one will usually be needed for the margin of the nostril.

So-called hare-lip pins are never required, nor is strapping ever needed to support the wound.

Dressing and After-Treatment.—The wound having been well dried with small pieces of fine sponge, the surface is dusted with boric acid, and is covered with a strip of soft gauze. The

gauze may consist of several layers, and the component strip must be cut exactly to fit the part, and should not extend on to the cheek. A very slender piece of strapping will keep the gauze in place. Instead of the strapping the gauze may be kept in place by collodion or a solution of celloidin in alcohol and ether. Care should be taken lest the upper edge of the small dressing irritates the nostril, and it is not essential to employ a dressing in all cases. Merely dusting the wound with boric acid powder will suffice where there is no tension. As a rule, however, the use of gauze is advisable.

In the nursing of the case every care must be taken to keep the area of the wound as dry as possible, to keep the nostrils free from mucus so far as can be managed, and so to feed the patient that no strain falls upon the wound.

Young infants can be kept perfectly quiet for many days after the operation by the administration of repeated minute doses of chloral. Children so treated remain remarkably still, do not cry, and appear not to suffer the least harm from the use of the drug.

In patients a little older than the average of those who are subjected to this operation, steps must be taken to prevent the child from meddling with the dressing.

The wound should be inspected if there be any suspicion that it has become soiled.

As a rule none of the sutures need be removed until the seventh or eighth day. They may be removed on successive days.

At a later period a further plastic operation may be needed to improve the appearance of the parts, and especially to remove any notching which may occur at the free margin of the new lip.

Should the wound break down, the case should not be regarded as hopeless. The raw edges should still be kept approximated, and every assistance given to the process of granulation.

Comment.—The operation cannot be so well carried out, nor can the head be kept so steady, if the infant be held in the nurse's lap, as is not infrequently advised.

It is most essential that the lip should be well freed on both sides of the gap. If this be effectually done, there is no tension put upon the wound, and even in quite large clefts the pared margins are brought readily into contact.

The paring should be accomplished with a knife, and not with scissors.

The recommendation that as little as possible should be cut away is not one that should be followed. In paring the edges there must be no stinting. The fault of the young operator consists usually in removing too little rather than too much.

If the lips are pared as advised—the incisions terminating abruptly below—there is little risk of a notch forming when the scar contracts.

Some surgeons use silver wire for the median suture (i.e. the suture which commands the coronary arteries), employing gut or horsehair or silk for the other stitches.

Messrs. Jacobson and Rowlands call attention to the fact (" Operations of Surgery," 1907, vol. i., page 522) that " in some cases of hare-lip death from dyspnœa may take place very soon after the operation. Thus, where the cleft has been a large one, and the upper lip when restored is tight, when it overhangs the lower, if the nostrils are flattened and partially closed by the operation, owing to the tension of the parts, so little breathing-space may be left that temporary interference with respiration may occur, with grave and even fatal results before the breathing can be accommodated to the altered circumstances, and before the parts dilate and stretch." Mr. Jacobson records three cases of death after operation on hare-lip from this cause, one being under his care, and two under Mr. G. A. Wright of Manchester. When the infant shows signs of difficulty in breathing after the operation the nurse should depress the lower lip frequently with her index finger until the child gets used to the new conditions.

OTHER OPERATIONS FOR SINGLE HARE-LIP

Nélaton's Operation.—When there is only a slight notch in the lip, as shown in Fig. 257, this operation is very useful. Such a notch may be due to congenital defect, or may more frequently depend upon undue contraction at the site of a previous operation for hare-lip.

The notch is circumscribed by a **V**-shaped incision, which does not, however, involve the border of the lip. With fine-pointed forceps the piece so isolated is drawn downwards, so

that a diamond-shaped wound is produced. The opposite sides of the wound are united by sutures (Fig. 257).

The slight projection which is left at the edge of the lip will shrink and disappear in the course of time.

FIG. 257.—NÉLATON'S OPERATION.

Mirault's Operation.—When the edges of the flap are very unsymmetrical, and when they diverge considerably, the following operation gives admirable results:—

A flap is cut from the shorter or more vertical margin of the cleft. It is free above, and is attached below near to the red border of the lip (Fig. 258). It is most conveniently fashioned by transfixing the lip just above this border, and by allowing the knife to cut its way out at the upper angle of the cleft. This flap must be composed of the entire thickness of the lip, must be large and substantial, and not a mere paring from the edge of the cleft.

The longer or more oblique margin of the gap is then freshened by paring, and care must be taken that the raw surface is as wide as possible.

The flap is now drawn down and placed in position, and the wound closed by sutures (Fig. 258).

In this operation it is especially important that the separation of the lip, which has already been insisted upon (page 135), should be very freely carried out. It may be necessary to detach one or both alæ. The edges of the gap must be approximated without tension. A common fault in this procedure consists in making the flap too small and scanty.

FIG. 258.—MIRAULT'S OPERATION.

Hagedorn's Operation.—With a sharp-pointed knife the incision 3-4-2 (Fig. 259) is made on the lateral side of the cleft, and the incision 4-3-2 on the median margin. Finally, with a pair of sharp scissors, the incisions 5-1-4 are made upon each

side of the defect. The margins of the gap thus isolated are removed, i.e. the whole of the margin from 5 to 2. The raw surfaces are then adjusted as shown in the left-hand diagram in Fig. 259. By this it will be seen that the points which were before on each side of the cleft, and which are indicated by corresponding figures, are brought together—i.e. the point marked 3 on the right side is united to the point marked 3 on the left side, and so on. Or the incisions may be disposed as

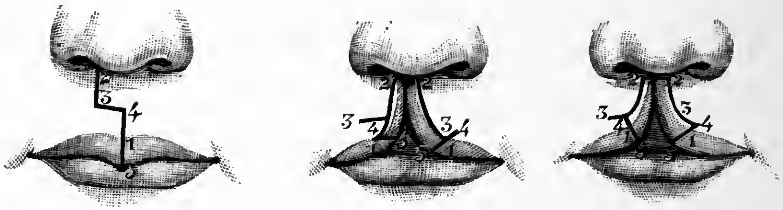

FIG. 259.—HAGEDORN'S OPERATION.

shown in the right-hand diagram in Fig. 259, the points upon each side of the cleft, which are indicated by corresponding figures, being brought together.

It is unnecessary to describe here other complicated forms of incision which have been advocated from time to time; the methods already described and figured, modified perhaps by the surgeon to suit the individual case, will amply suffice. It is important to leave as inconspicuous a scar as possible, and to take the greatest pains in leaving an even red margin to the lip. Some methods of incision, such as that described by Prof. König, involve a large transverse scar which is most unsightly.

DOUBLE HARE-LIP

The operation required in cases of double hare-lip is of the same character as that already described.

In many instances the defect is more easily remedied when it is double than when merely a single gap exists. In the most favourable forms of double hare-lip the sides of the cleft are symmetrical, and are, moreover, more nearly parallel than is the case in single hare-lip.

A malplaced pre-maxillary bone is the most troublesome complication met with in dealing with this deformity.

Form of the Hare-Lip.—From the point of view of operation, Sir T. Smith divided double hare-lip into the three following varieties :—

1. When the premaxillary bone is *in situ*, and the two clefts are simple and fairly bilateral.

2. When the premaxillary bone is separated from the rest of the jaw, and projects forwards, in some cases slightly, in others being attached to the vomer, and hanging from the tip of the nose.

3. When the premaxillary bone is small and ill-developed, and the clefts are widely gaping.

The following are the operations adapted for the three varieties :—

First Variety.—In this simple form the skin over the premaxillary bone is freed from its deep attachments behind, and its edges are pared so that it receives a **U**- or **V**-shaped outline. The margins of the lip on each side are then pared in the manner already described (page 135). The portions of the lip may or may not need to be freed from their attachments (Fig. 260). The raw edges are finally united with silkworm-gut sutures. Owing to the small size and the shape of the central piece, the resulting wound is more or less **Y**-shaped.

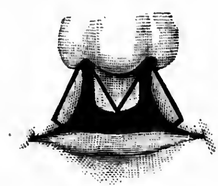

FIG. 260.—OPERATION FOR DOUBLE HARE-LIP.

In order to avoid the notching which not infrequently occurs in the median line, when cicatrisation has taken place after this operation, thick flaps with square ends may be cut from each margin of the main cleft, as shown in Fig. 261. These flaps have their attached ends downwards. They are united to the raw margins of the central segment above, and to one another along what is now the new margin of the lip. The segments of the lip will need to be freed from their deep connections on each side of the cleft.

Hagedorn's modification of the usual operation is illustrated in Fig. 262, and can be best understood by a study of the diagram. The soft parts covering the premaxillary bone are pared liberally. The raw margin produced is bounded by the incision 4-*a*-1-*o*-4.

The margins of the cleft are pared in the manner shown. The part actually removed in the freshening process is left unshaded in the diagram, and is bounded by the incision 4-2-3. The lateral cuts $a'1$ and $o'1'$ are nearly parallel with the free margin of the lip.

FIG. 261.—OPERATION FOR DOUBLE HARE-LIP.

The raw edges are united in such a way that points marked in the figure by corresponding numbers are brought together by sutures (Fig. 262).

Second Variety.—In this variety the projecting premaxillary bone offers a serious obstacle to the proper closure of the cleft by operation.

Many very different plans have been proposed for dealing with this unfortunately placed piece of bone.

It is needless to consider these various methods in detail; many are obsolete, many differ from one another in but the most insignificant feature.

The experience of the past and the expressed opinion of most living authors are practically unanimous upon one point,

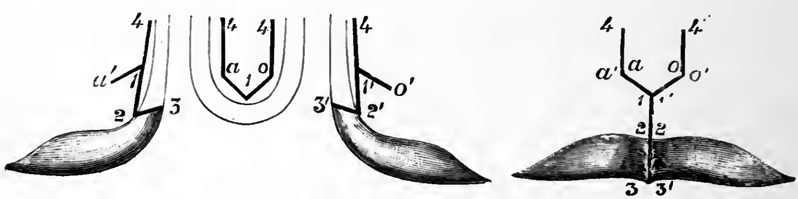

FIG. 262.—HAGEDORN'S OPERATION FOR DOUBLE HARE-LIP.

viz. that the premaxillary bone should be preserved whenever possible, and that its excision is a procedure to be condemned. If this little piece of bone be removed, a permanent gap is left in the hard palate, the upper lip tends to become flattened, malplaced, and unsightly, and is liable to be retracted on inspiration. The patient loses a point which might prove useful in supporting false teeth. There occurs in time a want of correspondence between the upper and lower dental arches, and the patient is said to be "under-hung."

The following courses may be recommended in dealing with this bone :—

(*a*) In the simplest cases the premaxillary bone may be forced back into line with the rest of the jaw. This may be done either with the thumbs or by using necrosis forceps with smooth blades protected by indiarubber.

This fracture can be effected when the attachment of the os incisivum is slender, and when there is room between the maxillæ to receive the displaced fragment.

If it tends to protrude after such fracture, the bone may be held in place by cutgut sutures attached to the upper jaw.

If the maxillæ offer no space to receive the fractured fragment, a bed for the bone may be made by removing small portions of the maxillæ with the chisel, and then fixing the fragment in position with sutures.

(*b*) Very usually the bending back of the bone is resisted by the cartilaginous vomer of children, and the elasticity of that structure causes the fragment to be again protruded when the pressure is removed.

In such a case a portion of the vomer may be excised subperiosteally, as advised by Bardeleben, Guérin, and others. An incision is made along the free border of the septum, leaving its arteries intact : the periosteum and mucous membrane are then elevated on either side, and a triangular segment is excised from the vomer. The os incisivum may now be pushed into place, and may be retained, if needed, by one or more sutures.

The bleeding in this operation is apt to be free, unless the subperiosteal method be closely adhered to.

(*c*) Should a case occur in which by no method yet named the little bone can be reduced, then the mucous membrane covering it may be incised, and the main part of the bone, together with the temporary incisors, scooped out with a gouge. After such a measure, which was advised by Sir William Fergusson, little but periosteum and a thin plate of bone would remain.

The method described under (*b*) is the best one to adopt in most cases, and has given excellent results in our experience.

After the reduction of the bone, the gap is closed by one of the methods already advised.

Third Variety.—In the last of the three varieties named, the two margins of the lip have merely to be brought together and united to one another and to any portion of the central segment which may be available. To effect this, an extensive separation of the lip, and possibly of the cheek, on either side, will have to be carried out, for until the soft parts have been well freed from the underlying bones no approximation is possible.

V. Plastic Operations to remedy Certain Defects of the Lips

The defects here dealt with are, for the most part, such as result from the removal of epitheliomatous growths by operation, and losses of tissue due to destructive ulceration, to lupus, to burns and to injuries, and notably to gunshot wounds.

The defects will be mostly of triangular or quadrilateral outline.

The operations proposed, or actually carried out, in these cases are very numerous, and, in many instances, very complex. No one operation, nor even one method of operating, can meet the requirements of every case. Every individual example must be taken upon its merits, and much must be left to the judgment and ingenuity of the operator.

General Observations.—In all these operations great care must be bestowed upon the sutures, and especially upon those which fix the new margin of the lip. The sutures should include all the tissues except the mucous membrane.

A few fine silk sutures involving the mucous membrane only may be inserted along the free margin of the lip. The best material for the main stitches is silkworm gut.

Hare-lip pins are rarely required. They must be fine, and made of good steel, so that they cannot be bent out of a straight line. The thread fixing the pin should be of silk applied in a figure of 8, and as short a length as possible should be applied. The great mass of silk ligature sometimes twisted about hare-lip pins is capable of producing some sloughing from pressure, and of interfering with the healing of the wound at the most important part.

Hare-lip pins should be avoided whenever possible, and if the

tissues upon each side of the gap to be closed are well freed, their employment may be less often imperative.

A large proportion of these operations are performed upon old persons, in whom the tissues are lax and extensile.

The bleeding during the operation is arrested by compressing the coronary arteries, which is done either by the finger and thumb of an assistant or by special forceps or clamps.

One of the sutures or one hare-lip pin must be so introduced as to command the coronary arteries when the wound is adjusted.

Any carious teeth in the jaw, and especially diseased incisors, should be removed before the operation, and the mouth placed in as healthy a condition as possible.

In adult males the parts must be carefully shaved.

A dry dressing of the simplest character should be employed. Powdered boric acid, and a little dry sterilised gauze kept in place by collodion or celloidin solution (in alcohol and ether), answer well.

Hare-lip pins should be removed on the third day, if not before.

It is important that the mouth be kept well and frequently washed out. Discharge—which the patient has no power to expel—is apt to accumulate between the cheeks and the lower jaw, and behind the lower lip. It is retained, and decomposes. The mouth should be frequently flushed out with an irrigator, and still more frequently rinsed out by the patient. One of the best solutions, both for the irrigator and as a mouth-wash, is a one in sixty or a one in eighty solution of carbolic acid.

THE LOWER LIP

1. **The Closure of Wedge-shaped Defects by the Method of Gliding** or **Lateral Displacement.**—So long as the base of the triangular defect is less than half the normal width of the lip, the surgeon may bring the edges of the freshened wound together and unite them by sutures. Even if the defect involve more than half the width of the lip, direct union by sutures may often be carried out, especially in old subjects with relaxed tissues and possibly edentulous jaws. If the defect be median, no loss of symmetry will be observed; but if—as is often the case—

one lateral portion of the lip be involved more than the other, then some traction upon one corner of the mouth will follow, and the aperture will tend to become rounded on the affected side. The form of the mouth may be left considerably distorted, and the aperture be too small.

In order to remedy undue contraction of the oral aperture the following method may be carried out. It can be done on one or both sides; we will suppose that the former will suffice.

An incision is made in the cheek, starting from the oral angle and directed horizontally outwards. This cut involves the whole thickness of the cheek upon the distorted side. The mucous membrane upon each side of this new wound is reflected a little, and is then united to the skin by sutures, so that the raw surfaces are covered. In order that the new angle of the mouth should also be lined by mucous membrane, a small triangular flap of mucous membrane, with its apex directed forwards, is raised by means of two divergent incisions. This flap is drawn into the angle and secured with fine sutures.

In dealing with defects of considerable size and of triangular outline, one or other of the methods of gliding already described (page 105 *et seq.*) may be employed.

In the case of a large median defect the incisions made would be symmetrical, i.e. a curved incision, starting from the angle of the mouth and ending at the lower border of the jaw, would be made upon either side. The flaps thus marked out would be joined in the median line after they had been well freed from the parts beneath.

2. **The Closure of Quadrilateral Defects, and the Restoration of the Lower Lip by means of Flaps.**—(A) *Langenbeck's Operation.*—The lower horizontal margin of the defect is prolonged on either side by incisions, which pass along the remainder of the lower lip, round the angles of the mouth, and into the upper lip, in the manner shown in Fig. 263, A. The broader the defect to be closed in, the nearer must the incisions approach the median segment of the upper lip.

This segment, however, must always be left intact, so that the communications between the coronary vessels and the arteries of the septum may not be disturbed.

The portions of the lips thus marked out are mobilised, and are

drawn together towards the symphysis of the lower jaw, and are there united by sutures. Sutures must always be placed at the new angles of the mouth, in order to preserve the normal outlines. The rest of the wound is finally closed (Fig. 263, B).

This method is not adapted for cases in which the loss of substance extends downwards beyond the movable part of the lower lip. In

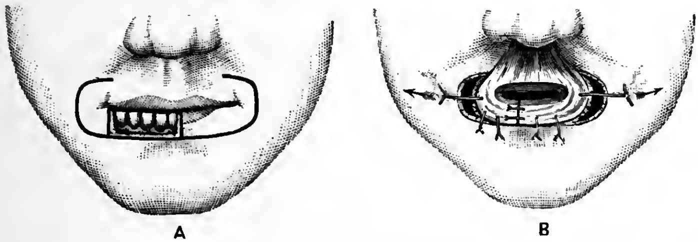

FIG. 263.—RESTORATION OF THE LOWER LIP: LANGENBECK'S OPERATION. (*After Löbker.*

such instances it would be impossible to detach the upper lip sufficiently, and even if that could be carried out the oral aperture would be too small.

(B) *Esthlander's Operation.*—This method may be employed when the loss of substance in the lip is partial, and on one side, and when the defect extends downwards to the skin over the chin.

A triangular flap is so fashioned from the upper lip that its pedicle or base contains the coronary artery, while its apex is situated on the cheek (Fig. 264, A).

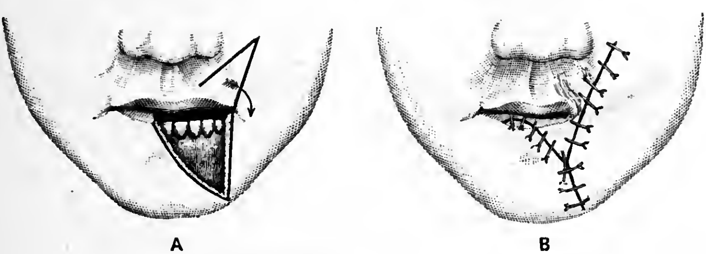

FIG. 264.—RESTORATION OF THE LOWER LIP: ESTHLANDER'S OPERATION. (*After Löbker*

This flap is then turned downwards, so that its apex comes to occupy the lower angle of the defect.

It is here fixed by sutures. The gap left in the upper lip is closed by suitable stitches (Fig. 264, B).

Both in this and in the preceding measure a lining of mucous membrane is obtained for the new lip edge.

(C) *Bruns' Operation.*—Bruns' method may be carried out when the whole breadth of the lower lip has to be restored, as shown in Fig. 265.

Here two quadrilateral flaps are fashioned out of the whole thickness of the cheek and upper lip, and are placed one on each side of the mouth.

They will receive a liberal blood supply from the facial arteries.

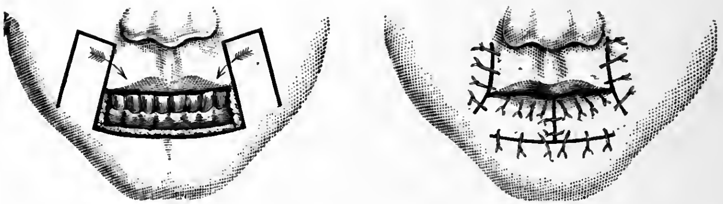

FIG. 265.—RESTORATION OF THE LOWER LIP: BRUNS' OPERATION. (*After Löbker.*)

After having been mobilised, they are so turned downwards that their upper borders can be sutured together in the median line.

It may be possible to adjust the mucous membrane lining these flaps in such a way as to provide a mucous covering for the margin of the new lip (Fig. 265).

The wounds on the cheeks are finally closed by sutures.

(D) *Operations by Flaps derived from the Chin.*—When the tissues

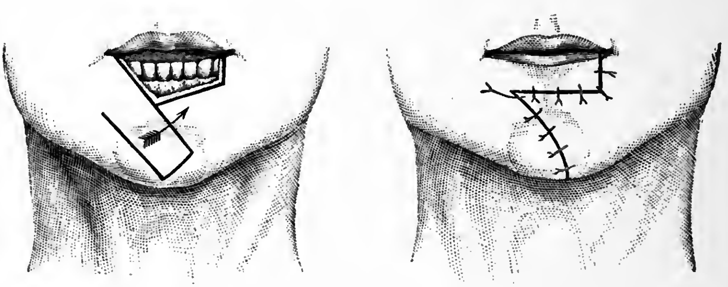

FIG. 266.—RESTORATION OF THE LOWER LIP: LANGENBECK'S OPERATION. (*After Löbker.*)

of the cheek or of the upper lip are unsuited or unavailable for flap formation, use may be made of the integuments of the chin.

The skin of this part is well adapted to form a sound flap, but in these operations a lining of mucous membrane is wanting in the flap, and consequently must be lacking—in the first instance at least—in the new lip. The flap may be single or double.

(1) Langenbeck's Method by Single Flap.—One of the margins of the defect is cut obliquely, and is prolonged downwards as an incision through the tissues covering the chin. Its length must depend upon the size of the deficiency in the lip.

Between this incision and the lower border of the defect a triangular piece of skin remains, which serves subsequently to support the flap. By means of two other incisions, which meet at right angles, a flap is formed with its base or pedicle upwards and outwards (Fig. 266). This flap is detached, is displaced upwards, and is secured in place by sutures. The wound in the chin is closed in like manner.

(2) The Method of Syme and Buchanan by Double Flaps.—Each flap is made to correspond to one-half of the new lip, and is formed by prolonging the edges of the defect downwards by two incisions which meet and cross obliquely (*a b c′*, *a′ b c*, Fig. 267). Their length will depend upon the size of the gap to be closed after due allowance has been made for shrinking. From their lower ends two other incisions are made at right angles (*b c*, *b c′*, Fig. 267), and the flaps are completed by two final incisions, *c d*, *c′ d′*. These flaps are liberated, and are turned upwards, so that they may be united in the median line along the lines *b c*, *b c′*. The broad support for the flap which is provided by Langenbeck's method is wanting in this operation. Two small triangular raw surfaces may be left below, and will be allowed to close by granulation. The central and prominent part of the chin is left undisturbed.

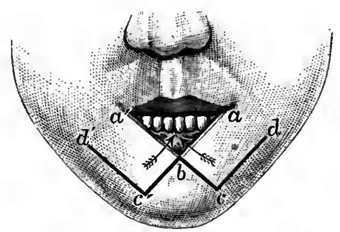

FIG. 267.—RESTORATION OF THE LOWER LIP: SYME AND BUCHANAN'S OPERATION. (*After Löbker.*)

Only in extreme cases is it advisable to make use of the skin below the chin, or that of the neck, in forming a new lip. In some cases of extensive epithelioma of the lower lip, in which it is impossible to save any of the latter, and in which the submaxillary lymphatic glands require excision, the following procedure should be carried out:

The growth is removed by two converging incisions, which meet above the prominence of the chin. From this point the knife sweeps downwards on either side of the middle line, curving below the submaxillary glands. The flaps are then raised and

all suspicious lymphatic glands dissected out (it may be sometimes advisable to remove the salivary glands as well, the facial vessels being ligatured). From each angle of the mouth two lateral incisions are now made passing outwards and downwards into the cheek, and thus the broad flaps can be freed, so that their inner edges can be sutured together in the middle line. A certain amount of puckering of the cheek must result, but it can be improved by excision of small wedge-shaped portions, and a good ultimate result obtained.

3. **Epithelioma of the Lower Lip.**—In operating on these cases we strongly advise excision of the chain of lymphatic glands lying in the submaxillary and submental regions. This is done as a preliminary measure before the lip is dealt with.

In order to remove the chain of lymphatic glands which extends from one angle of the jaw to the other, and in which epithelial deposits from the cancer are certain to occur, it is essential to clear the submaxillary triangles as well as the submental space. As shown in Fig. 269, it is possible to excise lymphatic glands and both salivary glands in one mass, and this affords the best guarantee against future recurrence.

The facial arteries are tied during this dissection, so that the later incisions made to remove the lip epithelioma are comparatively bloodless. It is useless to attempt excision of the submaxillary lymphatic glands without at the same time removing the salivary ones, so closely are they blended. Fortunately, the loss of both the salivary glands causes little or no subsequent inconvenience, and little if any disfigurement results from the submaxillary scars.

Steps of the Operation.—As noted, the actual tumour of the lip is left to be dealt with at the end.

(1) The patient's head is turned well over to one side, and the chin held up by an assistant. A curved incision is made from the tip of the chin down to the hyoid bone, and then up to the angle of the jaw. The flap, consisting of skin, fascia, and platysma muscle, is secured with a stitch-retractor and dissected up to the level of the border of the jaw. The deep fascia encasing the submaxillary gland is divided in the same line, the facial vein being ligatured doubly and divided.

(2) The submaxillary gland is cleared, partly by blunt dissection, right up to the angle of the jaw. The facial artery is sought for as it emerges high up from under the digastric muscle to enter the submaxillary gland. The artery is securely ligatured with fine silk and divided. The gland is displaced forwards and the connections of its fascial sheath with the border of the jaw are severed until the front edge of the masseter is reached. Here

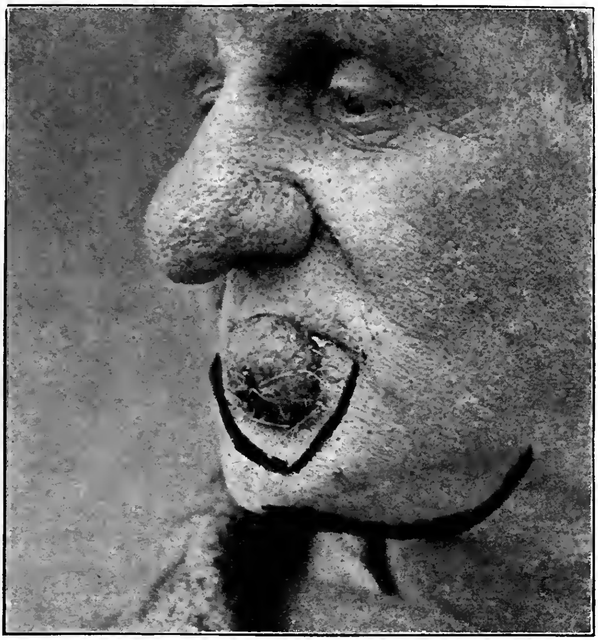

FIG. 268.—OPERATION FOR REMOVAL OF EPITHELIOMA OF LOWER LIP AND FOR CLEARING THE SUBMAXILLARY SPACE.

The incisions are shown as strong black lines.

the branches of the facial artery lying close to and in front of the facial vein are met with again as they rest on the jaw. They are isolated and tied, or else clamped and divided.

The contents of the submaxillary triangle being still further raised and drawn forwards, the gustatory nerve is exposed; its branches to the ganglion and gland are then divided. Wharton's duct is ligatured and cut, and the mylo-hyoid muscle cleared, as well as the anterior belly of the digastric.

All bleeding vessels, and many will have been met with, are

ligatured, and the forceps removed. A pad of sterile gauze is inserted in and around the wound.

(3) The patient's head being turned over, the operator works from the opposite side, exactly repeating the dissection.

His two incisions meet in the median line, leaving a pointed strip of skin, which covers the submental space. It is of great importance to clear this region from the lower jaw to the hyoid. It can readily be done if the flap is drawn downwards and the lateral dissections continued until they meet. Four lymphatic glands, directly draining lymph from the median portion of the lip, will thus be removed.

(4) The epithelioma of the lip is now dealt with. It is useless to lay down rules as to the exact form of incision, the only im-

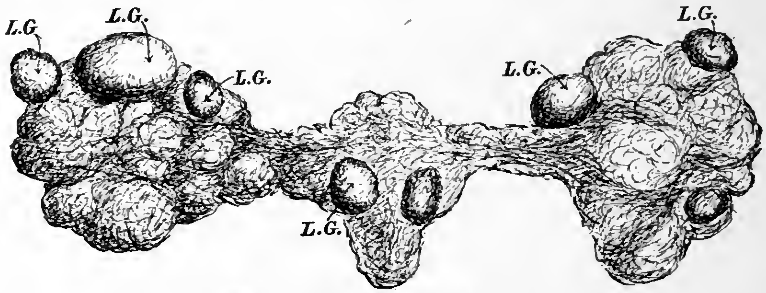

FIG. 269.—FROM A CASE OF EPITHELIOMA OF THE LOWER LIP.
The parts shown were removed in one mass; they include both submaxillary (salivary) glands and a number of lymphatic glands (L.G) in both lateral spaces and in the submental one.

portant point being to keep well clear of the growth, half an inch from its edge all round.

An incision like a capital **U** is generally employed. Advanced cases may require removal of almost the entire lower lip. The surgeon must be free with his incisions, trusting to plastic procedures to fill the gap.

The submaxillary incisions have not yet been closed, and they may be utilised as stated above (page 109), to enable the skin over the chin to be brought up to the mouth.

As a rule, however, the incisions above and below the jaw are kept distinct.

Drainage-tubes, spiral by preference, should invariably be placed in the neck incisions. Silkworm gut is employed for all three wounds.

Healing is, as a rule, rapid, and subsequent deformity, however extensive the excision, will be but slight. There is no part of the body that "settles down" after such operations better than the lower lip and submaxillary regions.

Comment.—The above operation is obviously a tedious one compared with the rapid, almost theatrical, method of dealing with epithelioma of the lip which was practised in former times. It is impracticable to complete the dissection under an hour or more. But the time is very well spent, for in epithelioma of the lip, as in that of the tongue, the great danger lies in early infection of lymphatic glands. Removal of every gland which is likely to be infected can be secured by the above method, and to wait until they have grown to be of fair size is to deprive the patient of all reasonable chance.

This radical operation was brought forward in a paper by J. Hutchinson (*Brit. Med. Journ.*).

THE UPPER LIP

Plastic operations are less frequently called for in the upper lip than in the lower.

Defects of small size may be closed by certain of the general methods already described (page 105 *et seq.*), and in a few instances by operations akin to those above detailed, as performed upon the lower lip. The following special operations represent the most typical of the very numerous plastic measures which have been advised or carried out in this part.

1. **For Partial Defects.**—(A) *The Central Part of the Lip is Deficient* (Dieffenbach's Operation).—The central part of the upper lip may be deficient, and an obtuse-angled triangular defect exist, with its apex below the nose, and with its edges covered with mucous membrane.

FIG. 270.—RESTORATION OF THE UPPER LIP: DIEFFENBACH'S OPERATION.

Two curved incisions start from the apex of the defect, and are carried round the alæ of the nose in the manner shown in Fig. 270. These incisions, together with the

margins of the defect, mark out two flaps. These are detached from the subjacent parts, and are brought together in the median line (Fig. 270). The mucous membrane, which marked the borders of the defect, is preserved, and serves to form the free margin of the new lip.

(B) *The Angle of the Mouth is distorted by Cicatricial Contraction, or is occupied by a Growth* (Serre's Operation).—Incisions are so made (Fig. 271) as to mark out two triangles, which meet by their bases at the site of the new angle of the mouth.

FIG. 271.—SERRE'S OPERATION FOR RESTORATION OF THE ANGLE OF THE MOUTH.

When the tissues thus circumscribed have been excised the edges of the wounds are united as shown in Fig. 271. The adjacent integuments are drawn together, a vertical and a transverse incision being the result.

2. **The Whole of the Upper Lip requires to be restored.**—(A) *Operation by Lateral Flaps* (Szymanowski's Method).—Lateral flaps of the full breadth of the lip are cut from the cheek on each side. Their outer extremities are curved downwards, so as to relieve

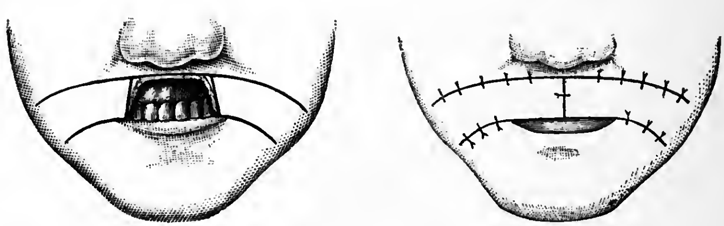

FIG. 272.—RESTORATION OF THE UPPER LIP: SZYMANOWSKI'S OPERATION.

them from tension. After they have been detached their inner extremities are brought together and united in the median line (Fig. 272).

(B) *Operation by Vertical Flaps* (Sédillot's Method).—Flaps of quadrilateral outline are raised by the use of the following incisions :—An

internal one (*a b*, Fig. 273) starts from a point midway between the angle of the mouth and the lower eyelid, and ends a little above the prominence of the chin. An inferior horizontal incision (*b c*) passes outwards from the lower end of the internal incision for a distance of about one inch and a half. An external incision (*c d*) runs upwards from the outer end of the last wound to a point on a level with the ala of the nose. The two flaps comprise the whole thickness of the

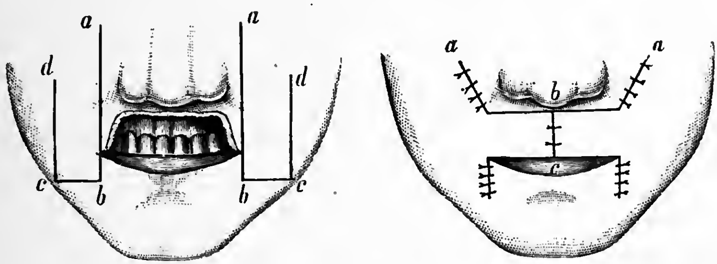

FIG. 273.—RESTORATION OF THE UPPER LIP: SÉDILLOT'S OPERATION.

cheeks, and after detachment are displaced inwards, so that their lower extremities (*b c*) meet in the median line (Fig. 273).

(c) *Dieffenbach's Method.*—In this operation the flaps have their free ends directed upwards instead of downwards. A vertical incision (*a b*, Fig. 274) is made upwards from the angle of the mouth to a point above the level of the nostril; then a horizontal cut (*b c*) extends

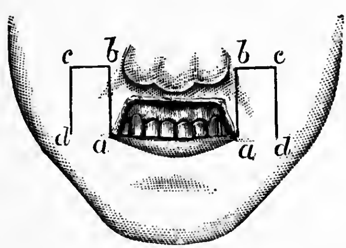

FIG. 274.—RESTORATION OF THE UPPER LIP: DIEFFENBACH'S OPERATION.

outwards more than equal in width to the defect to be remedied. The quadrilateral flap is completed by a vertical incision (*c d*) parallel to the first and ending beyond the angle of the mouth.

The flaps are detached, and are united by their upper extremities (*b c*) in the median line, after the manner of the previous operation (Sédillot's).

VI. Operations for Cleft Palate

These operations are among the most brilliant of those which belong to plastic surgery. They are concerned with the closure of clefts of all kinds in the palate, but are for the most part limited to the congenital cleft. Perforations in the palate, when due to disease, are usually dependent upon syphilis, and are not suited for operation unless the health of the patient be sound at the time. In selected cases large defects in the soft palate, due to syphilis, may be closed, and the same may be said of small perforations of the hard palate. Large clefts in the hard palate in syphilitic subjects are not well adapted for operation, and are usually best treated by the introduction of an obturator. In any case, it is well that an antisyphilitic treatment be carried out for some little time before the operation.

Extent of the Cleft.—The extent of the defect may vary from a bifid uvula to a cleft involving the whole of the soft and the hard palate, and which, passing through the alveolus on one or either side of the os incisivum, ends in a hare-lip. The cleft may be limited to the soft palate, and if the velum be entirely divided there is usually some want of union at the same time between the palate bones. Clefts limited to the hard palate are almost unknown, and when existing are represented usually by certain congenital holes.

The defect in the hard palate may be limited to the palate bones, or may extend as far as the apex of the intermaxillary bone, or may be completed by the division of the alveolus.

The defect is usually somewhat to the left of the median line, and the septum nasi—when the hard palate is involved—is commonly adherent to the margin of the palate process of the right maxilla. In severe cases the bony septum may be quite free below from connection with any part of the palate.

Circumstances affecting the Operation.—The severity of any given case (from the point of view of operation), and the difficulty that may attend an attempt at closure, will depend not so much upon the length of the cleft as upon its width in relation to the amount of tissue available for closing it. In the soft palate the velum on either side of the cleft may be, on the

one hand, of considerable width and substance, or it may be, on the other, shrunken, small, and attenuated.

In the hard palate a great deal depends upon the height or pitch of the vault.

In cases of highly arched palates which on transverse section would resemble a Gothic arch, the dissecting-up of the flaps is comparatively easy, and their approximation a matter of little difficulty. If, on the other hand, the palate be but slightly arched, there is difficulty in obtaining substantial flaps, and still more difficulty in bringing them together. Prof. Howard Marsh (*Lancet*, July 7th, 1888) well illustrates this by a simple figure. "Supposing that in each of two cases the cleft is half an inch wide, and that in one the arch takes the direction A B C D, and in the other the direction A E F D (Fig. 275, 1). When the soft parts are brought together the flaps A B and C D will be too short

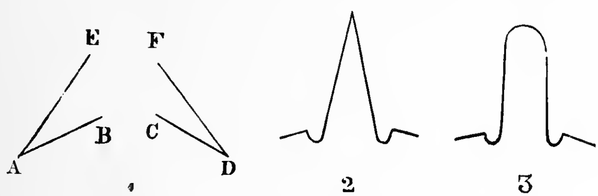

FIG. 275.—VARIETIES OF CLEFT PALATE.

to bridge over the gap; but when the much longer flaps A E and F D are brought down, they will meet easily, and even overlap." The manner in which the cleft of the hard palate terminates anteriorly is a matter of great moment. If it ends in a point like a thin wedge (Fig. 275, 2), the shape is favourable. But if the anterior end is rounded "like the bow of a hair-pin" (Fig. 275, 3), as Prof. Howard Marsh expresses it, the operation is a difficult one. The union of the septum nasi with one maxilla is a favourable condition, since there will be furnished for one side of the cleft at least an abundant flap.

With regard to the best time for the operation, as well as to the most suitable method of performing it, considerable difference of opinion prevails amongst surgeons with extensive experience.

Brophy, of Chicago, introduced in 1901, an entirely novel method of closing the gap by forcing together the superior maxillary bones by means of a loop of silver wire (*Dental Cosmos*, April, 1901). This can only be effected when the bones are soft

and elastic, i.e. during the first three months of life. Mr. Edmund Owen and other English surgeons have adopted Brophy's plan in some cases, but owing to the fatalities that have resulted, the method has not met with wide adoption. We shall briefly describe Brophy's method later, and will here only repeat that it is impossible except at a very early age.

The general teaching with regard to operating on a complete cleft, i.e. involving both hard and soft palate, has been that the third year is the most suitable time. This has the support of the late Sir T. Smith (who was one of the greatest authorities on these operations), Mr. G. A. Wright of Manchester, Mr. Berry of London, Mr. R. W. Murray of Liverpool, and many American surgeons.

Cases are not uncommon in which the operation has been deferred until a more advanced age, and excellent results are then as a rule obtained, provided that after closure of the cleft the patient is carefully trained in the matter of clear voice-production. It is, however, asserted by some authorities, and especially by Mr. Edmund Owen and Mr. Arbuthnot Lane, that a cleft palate can hardly be operated on too early, that it is wrong to wait until a year or more has elapsed, and that the best time is within a few months after birth.

On this last point the observations of Sir Thomas Smith, who must be regarded as the chief authority on palate operations, may be quoted. He condemned very early operations. "Doubtless," he wrote, "the deformity can be cured in very early infancy, but, regard being had to the difficulty and even danger of the proceeding, and the many possible causes of failure at this period of life, it is prudent to postpone operative treatment. In the first three or four years of life clefts of the bony palate generally diminish greatly in width, especially at their anterior extremity where in the process of growth fissures in the alveolar arch may be observed to close altogether by coalescence of their opposite edges. Thus with the lapse of time the operation becomes less difficult of performance, and no longer dangerous. . . . In deciding the question as to the best time for operating, the difficulty of the operation, and the constitutional condition of the patient, must be taken into consideration.

"In healthy children, clefts involving the velum only, without deficiency of the soft parts, may generally be cured in the third

year of life. Fissures which affect the soft palate and more or less of the hard may, as a rule, be closed before the end of the sixth year if the cleft be not very wide, and there is a sufficiency of material for flaps.

"In cases of unusual local difficulty, or where the general health is feeble, or there is considerable infirmity of temper, the operation may need to be still longer postponed; but, if the case be curable at all, it is rare that this cannot be accomplished before the patient is twelve years of age.

"When, from one cause or another, the operation has been long delayed, though a successful union may be more easily obtained, the results as regards articulation will be less satisfactory."

As another writer expresses it, the simpler the cleft, and the healthier the child, the earlier the operation.

Order of Operation.—In cases of complete cleft it was at one time advised that the defect in the velum should be first closed, and that the hard palate should be dealt with at a later period. Sir T. Smith, however, advocated that the union of both parts of the palate should be attempted at one operation.

This practice we have always followed, and the results have shown that the recommendation is sound.

Sir T. Smith makes one proviso. "When the bringing together of the whole cleft in one operation would necessitate so free a division of the soft parts as to endanger the vitality of the flaps, it is advisable to close first that part of the cleft that can be most easily approximated, whether it be the hard or the soft palate. This, if successful, will secure for the remaining portion a large supply of blood in the subsequent operation."

Instruments and Suture Material.—Probably for no operation have more numerous, more elaborate, or more remarkable instruments been devised than for the treatment of cleft palate. The various plugs, gags, forceps, knives, and needles invented by one man or another are legion, and to them must be added a medley of lip-holders, palate-holders, suture-twisters, and the like. The majority of these instruments are now fortunately obsolete. The surgeon should be able to work with simple instruments, and if he be unable to suture a cleft palate without an armoury of complex tools, he had probably better leave the operation undone.

The following are the *instruments* required :—Two sharp-pointed tenotomy knives in long and slender handles, for paring the edges of the cleft. A blunt-pointed knife of the same kind, for making lateral incisions to relieve tension. Two pairs of long slender-bladed forceps, one serrated and one with tenaculum points. A pair of small sharp-pointed scissors curved to a quarter circle, for dividing the connection of the soft palate with the nasal mucous membrane at the posterior margin of the hard palate. Small blunt-pointed scissors, curved on the flat, for the sutures,

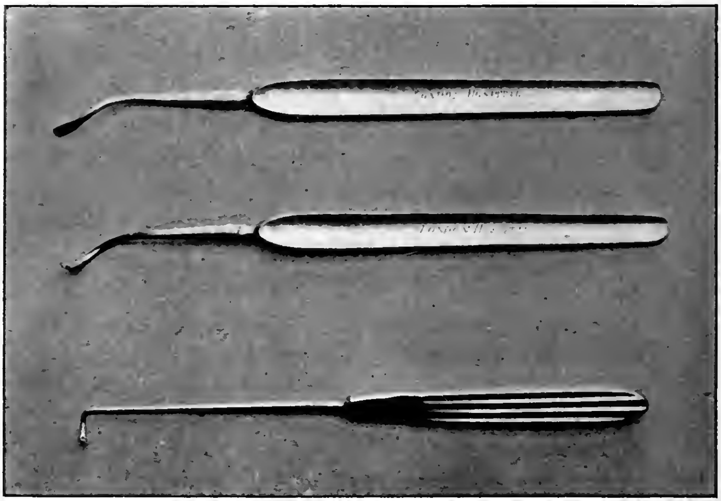

FIG. 276.—DURHAM'S CLEFT-PALATE RASPATORIES, WITH CLEFT-PALATE NEEDLE CURVED RIGHT AND LEFT.

etc. Two raspatories of different curves, such as are shown in Fig. 276, are necessary. They should be rather slender in make, as they can then be used for operating on patients of various ages. Many of the raspatories that have been devised are too heavy and clumsy.

Different surgeons will prefer different forms of needle-holders for passing the sutures. Mr. Lane uses small curved needles held in a special holder. Another form frequently used is a slender rectangular needle in one piece with the holder—the eye being close to the point.

Many surgeons find needles twisted like a ram's horn, set in a handle, and with an eye near the point, most convenient.

For introducing silkworm-gut sutures rapidly Fitzgerald's needles (Fig. 277) will be found useful.

A loop of the gut is held in the needle, which has the slot directed towards its point. The needle is then thrust through one side of the palate, and the other needle passed unthreaded through a corresponding point on the opposite side of the cleft. With this second needle the loop is caught in the slot, and both needles are then withdrawn. With slight practice the operator will find this method to be one of the most rapid.

A gag is needed, and here again the surgeon's individual preference will decide the form to be used. Sir T. Smith's well known gag combines a tongue-depressor with a screw-adjuster for opening the mouth on each side. We have found this takes

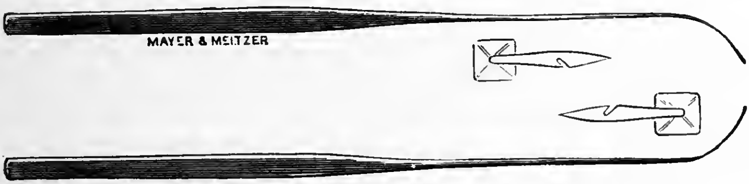

FIG. 277.—FITZGERALD'S CURVED NEEDLES FOR STAPHYLORRAPHY.
The ends of the needles are shown on an enlarged scale. The one with the slit pointed forwards is for introducing the loop of silkworm gut, the other for withdrawing it.

up too much room, and that the tongue depressor is apt to embarrass the patient's breathing, and we prefer a simple gag, which can be introduced first on one side of the mouth and then the other. If the tongue gets in the way it is best to pass a loop of suture through it in the middle line, and thus to draw it downwards and forwards. Or a small spatula may be used for the purpose.

A number of small Turkey sponges in sponge-holders are required, and the necessary material for the various sutures.

With regard to the *suture material*, much must depend upon the custom of the individual surgeon. Horsehair answers admirably for the uvula, and for the lower and flaccid part of the velum. It is distinctly not suited for any part where there is tension. The sutures should be of full length, should be carefully selected, and should be softened before the operation by immersion in

warm sterilised water. Horsehair sutures should be tied in three knots.

For the principal sutures—for those that have to bear strain—silkworm gut answers admirably. It causes, as a rule, no irritation. It should be prepared by immersion in hot water. The fine gut should be used, as it can be readily knotted.

Position of the Patient.—The upper part of the body must be well raised, and the head be placed sufficiently high to prevent the surgeon from stooping. The head should rest upon a hard cushion, or be received in a depression in a sand-bag. It must be thrown well back. The table should be narrow. The surgeon stands on the right, facing the patient. The anæsthetist takes his place on the left. One assistant, standing at the end of the table, fixes the patient's head and attends to the gag; a second assistant, at the surgeon's side, assists in the operation.

It has been advised that the head be thrown back so far that the vertex points towards the ground. By such means the palate is rendered horizontal and is under the surgeon's hands. Blood also cannot run down into the trachea. This posture is not so convenient as it may appear, is apt to cause great engorgement of the head, and will be found in practice to have little to recommend it.

The question of the anæsthetic is important, and a practised and skilful anæsthetist is essential to the successful work of the operator. During the actual operation, chloroform is generally given by a Junker's inhaler and nasal tube, or else on a flannel mask used intermittently. The danger of chloroform, however, makes it advisable that ether should be given until the patient is under, as thereby the risk of heart failure is decreased.

When the operator stops to allow the anæsthetist to work, pressure should be made on the bleeding edges of the palate by means of sponges on holders.

OPERATION ON THE SOFT PALATE

The gag having been introduced, the first step is to pare the edges of the cleft. The tip of one half of the uvula is seized with the tenaculum forceps, and is drawn upon so as to make

the palate tense. With a sharp-pointed knife the edge is now pared from below upwards, *i.e.* from the free margin of the velum towards the hard palate. The knife may follow the anterior angle of the cleft (assuming the hard palate to be sound), and may return in the opposite direction along the other margin of the cleft, that side of the velum being made tense in turn.

The whole of each side of the cleft must be well and liberally freshened. The anterior angle of the cleft and the tip of the uvula are especially apt to escape the knife. The raw surface should be wide, and of even breadth throughout.

Scissors should never be used to freshen the edges.

There will probably be no need for the flaps to be again touched with the forceps when this stage has been completed.

The next step is the passing of the sutures. They should be introduced from below upwards. The first suture is passed through the halves of the uvula, and the two ends are held in a pair of Wells' forceps, so that it may be used to make the edges tense, and thus avoid any handling of the palate with forceps. The same course is adopted with the ends of each suture, so that when the moment arrives for tying them all there can be no confusion between the various sutures. Each Wells' forceps grasps the corresponding ends of a single suture.

The sutures must be placed at a sufficient distance from the margin of the gap to secure a good hold, and their number and arrangement must depend upon the degree of tension at any particular point.

The sutures should, whenever possible, be passed through to both sides of the palate at one transit of the needle. The finer sutures (those for the uvula, for example) are passed by means of the rectangular needle, the others by one of the needles in handles used for carrying wire or silkworm gut. If the edges of the cleft will come together, the sutures should be fastened off at once by tying.

If the cleft be narrow, the sutures can be passed without difficulty. If it be wide, some special method may have to be adopted.

The following is the most convenient :—A very long suture has a needle threaded at either end of it. One needle is passed through the left flap of the palate from behind forwards, and

the other through the right flap in the same direction. The first needle passed must be held by an assistant while the other is being introduced. The needles employed should be small and curved, and must be passed by means of a simple needle-holder. Needles of various curves should be at hand. In no operation is a complex needle-holder more out of place than in this.

Avery's method for passing the sutures may be employed in these cases. It is executed as follows :—

A needle in a handle carrying a long suture is passed through one flap of the palate (say the left) from before backwards. The loop is caught when the point of the needle is in the cleft, and is drawn out of the mouth. The needle is then withdrawn, leaving the loop *in situ*. A long suture is similarly passed through the other flap (the right) of the palate. It is in like manner drawn through the cleft and out of the mouth, not in the form of a loop but as a single thread. The needle is withdrawn. The left half of the velum will therefore be pierced from before backwards by a loop of suture, the right half by a single thread. The single suture is passed through the loop. The loop is withdrawn, dragging the single suture with it. This suture therefore will have passed through the right half of the palate from before backwards, and through the left half from behind forwards.

"When there is too much tension to admit of the sutures being tied at once, they should all be passed, and, being held as described above, longitudinal incisions may be made on either side parallel to the cleft and just internal to the hamular process, avoiding the immediate neighbourhood of the posterior palatine foramen. It is well to make this incision with a blunt-ended knife, after puncturing the palate with a sharp-pointed knife. Sufficient relaxation being obtained, the remaining sutures are tightened up" (T. Smith).

If after the lateral incisions have been made the tension is not amply relieved, it is well to introduce a slender-pointed raspatory or vivisector's tool through the incision, and with it to detach the muscular and tendinous structures from the hamular process. We have found such a step always to answer its purpose completely.

Another method, advocated by Mr. T. Bryant, consisted in cutting with scissors from behind forwards each half of the soft palate near its lateral edge, so as to make a V-shaped gap on either side. This has the merit of simplicity, but it adds two wounds and disfigures the palate more than the method of lateral puncture referred to as Sir T. Smith's, which is really identical with the following.

Mr. Pollock divided both the levator and tensor palati muscles by means of a fine tenotome passed from before backwards through the velum just in front and to the inner side of the hamuiar process. The tenotome is made to act with a somewhat sweeping movement, dividing the tensor palati as it is spreading out into its fan-shaped insertion.

Throughout the operation, bleeding must be checked by gentle pressure with a sponge in a holder. The sponge should, however, be used as little as possible. The indiscriminate and persistent dabbing of the palate with a sponge tends to excite movement of the palatal and pharyngeal muscles, to produce vomiting and coughing, and greatly to increase the flow of saliva.

In the adult the saliva from the parotid may sometimes be seen to squirt in a jet into the mouth, after a vigorous sponging.

The operation may have to be suspended from time to time to give opportunities to the anæsthetist.

OPERATION ON THE HARD PALATE

Before describing this operation, it should be noted that partial or complete failure is not an infrequent result, and that the chief reasons for this are the following :—

1. Operating on subjects at too early an age, or those who are not in a satisfactory condition of health.
2. Damage to the blood supply of the flaps during the operation.
3. Secondary hæmorrhage.
4. Failure to unite, owing to the tension on the sutures not being overcome.

In some cases the supervention of scarlet fever or other illness may have prevented healing.

In order to avoid tension when the sutures are secured, it is necessary in all cases to lift up with a raspatory the flaps from

the cleft outwards for a considerable distance, in addition to making an incision just behind the hamular process to free the soft palate. Particular attention must be paid to the junction of the hard and the soft palate where the tissues are most firmly attached to the bone along the posterior edge of the hard palate. At this spot partial failure to unite is often met with in otherwise successful cases.

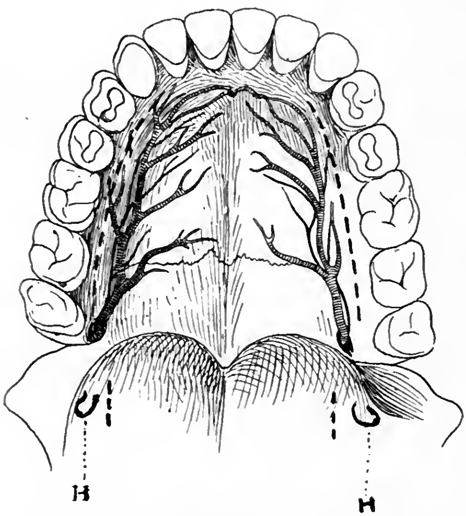

FIG. 278.—THE PALATINE ARTERIES IN RELATION TO THE OPERATION FOR CLEFT PALATE.

The dotted line on either side between the gum and the palatine artery and nerve shows where the incision should be made in order to displace these inwards uninjured in the flaps. H H, Hamular processes. A dotted line to the inner side of each hamular process indicates how the tensor palati may be divided so as to relieve tension.

The blood supply of the palate, both hard and soft, is almost entirely derived from the posterior palatine artery—a branch descending from the internal maxillary. The posterior palatine vessels emerge through the bone just internally to the socket for the last molar tooth, and the branch for the hard palate courses forwards to the incisive foramen, parallel to the alveolar margin.

The dotted line in the above figure shows where the incision should be placed—i.e. it must be just internal to the alveolar border and external to the groove for the artery already referred to. The incision goes right down to the bone, but should stop short in front of the last molar tooth, lest the artery should be wounded as it leaves the posterior palatine foramen.

The cases of serious and sometimes fatal hæmorrhage following the operation have been those in which the latter accident has occurred.

An additional incision will be required through the soft palate internally to the hamular process.

The steps of the operation are as follows:—

1. The edges of the cleft are carefully pared along its whole length on either side, the soft tissues being raised from their attachment to the hard palate and nasal septum.
2. One lateral incision just within the alveolar margin (*see* Fig. 278) is now made, and with a curved raspatory the whole of the soft tissues are carefully detached as far inwards as the edge of the cleft. At the back the raspatory is made to lift off from the bone that part of the soft palate where it joins the hard. This is best done from the cleft. The bleeding in this stage may have been considerable; it should be checked by pressure (made by the assistant with a sponge mounted on holder), whilst the operator proceeds to repeat the lateral incision on the opposite side. This incision is made in one case from before backwards, in the other from behind forwards. Sponge pressure will now be made on both sides, whilst the anæsthetic is resumed. The fauces need to be kept clear of blood by sponging, but this should be as sparing as possible, and done with the utmost gentleness.
3. The sutures are now introduced by one of the methods already described. The first will be passed through the soft palate at the base of the uvula. Traction made on this will steady the two halves, and ensure the others being placed at regular intervals. Fine silkworm gut is used, and the two ends of each suture are held outside the mouth in a Wells' forceps.

   The sutures should be placed at fairly close intervals, about 8 to 10 mm. apart.
4. Each suture is tied in order, but before tying the surgeon relieves tension as far as possible by the use of the raspatory, and by two short incisions through the soft palate made just within the hamular process. Especial attention should be paid to the extreme anterior end of the cleft, and to the point opposite to the junction of hard and soft palate. The knots made are single surgeon's ones, so that the ends lie

evenly against the palate and cannot irritate the tongue. The after-treatment of the case is described on page 174.

Note.—In the usual description of the operation the lateral incisions are placed more internally than above described—e.g. midway between the cleft and the alveolus. As Tillaux pointed out, the branches of the palatine artery are then cut across. Placing the incisions close to the alveolus presents no special difficulties, and diminishes the risk both of hæmorrhage and of sloughing of the flaps.

In some cases of acquired aperture in the palate, or in those in which an operation has left a small cleft remaining, a different method will suffice. The edges being pared, a small flap from one or other side is shaped out and brought over to cover the cleft, or two reversed flaps may be used after Davies-Colley's method (*see* page 169). In either case the flaps should be somewhat larger than the cleft to be covered over.

Modifications: The Use of Protective Material round the Flaps.—One of the undoubted causes of occasional failure is septic infection of the wound from germs in the secretions of the mouth. With the idea of preventing this, Prof. Stair of Toronto* advises wrapping round the detached and sutured flaps with thin aluminium plates—which are folded all round the flaps and only removed at the end of eight or nine days. Spraying with boric acid solution (and 10 per cent. rectified spirit) is advised by Stair. We have found that spraying the mouth in young children is unnecessary, and may be prejudicial. Stair only records the use of the aluminium plate in two or three cases, and the method seems to us clumsy and inadvisable. C. H. Mayo and C. H. Peck of New York had previously advocated binding round the flaps with tape, to prevent tension, but such a practice simply invites septic decomposition within the mouth.

Lannelongue's Operation by a Nasal Flap.—Lannelongue and other surgeons have occasionally closed a cleft limited to the hard palate by a rectangular flap obtained from the side of the nasal septum (*Bull. de la Soc. de Chir.*, 1877, page 472).

The size of the flap must depend upon the size of the gap to

* Stair, "A New Method of Dealing with Cleft Palate," *Brit. Med. Journ.*, June 29th, 1907.

be closed. It is limited by three incisions: one superior and horizontal, and two lateral and vertical. The base or pedicle of the flap is therefore at the lower border of the nasal septum. The flap is detached by a suitable rugine from above downwards. The lateral border of the fissure is pared, and the flap is then drawn across the cleft and attached to the freshened margin by sutures.

This plan may be carried out when the septum is adherent to one margin of the cleft, and where the opening is—with reference to the nasal septum—unilateral.

The case must be exceptional in which this excellent procedure will alone suffice to effect a cure, but the operation may be of great value in supplementing the usual measure as described above.

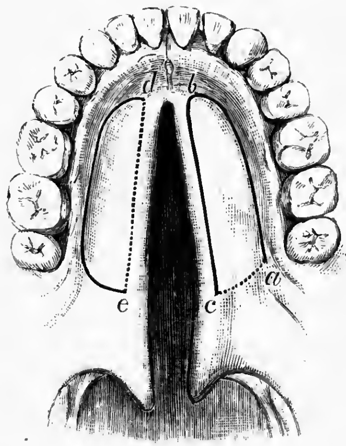

FIG. 279.—DAVIES-COLLEY'S OPERATION FOR CLEFT OF THE HARD PALATE.
The flaps (*a b c* and *d e*) marked out.

Davies-Colley's Operation.—This operation is described in the *Brit. Med. Journ.* for Oct. 25, 1890:—

First Stage.—A triangular flap (Fig. 279, *a b c*), consisting of the whole of the soft parts covering the bone, should be cut from that side of the hard palate which is the wider; or if, as usually happens, the septum of the nose is attached to the palatal process of one of the superior maxillæ, the flap should be taken from this side. The apex of this flap should reach nearly as far forwards as the insertion of the incisor teeth (*b*, Fig. 279). The outer border of the flap should begin just internally to the back part of the alveolar process, and should run forwards parallel to the margin of that process. The inner side of the flap should run backwards one-eighth of an inch externally to the margin of the cleft, and should terminate a short distance behind the posterior border of the hard palate. The base which is left attached will therefore extend from close to the inner border of the alveolus for the last molar teeth, inwards and slightly back-

wards to the edge of the cleft of the soft palate, near to its anterior attachment (*a c*, Fig. 279).

Second Stage.—An incision is made down to the bone upon the other side of the cleft, at least one-sixth of an inch externally to its margin. The greater part of the incision runs from before backwards parallel to the cleft. It should begin at the level of the anterior extremity of the cleft, and should end at the back of the hard palate (*d e*, Fig. 279). At its anterior and posterior extremities this incision should be carried inwards to the margin of the cleft. A raspatory is now inserted, and by it the muco-periosteum internal to the incision is separated from the bone as far inwards as the margin of the cleft.

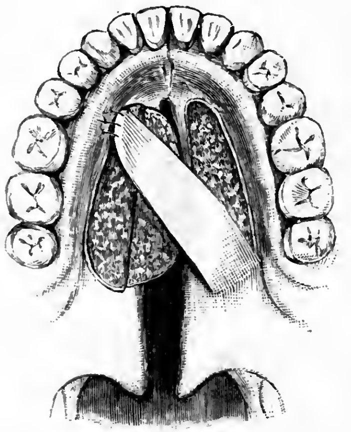

FIG. 280.—DAVIES-COLLEY'S OPERATION FOR CLEFT OF THE HARD PALATE.
The flaps in position.

Third Stage.—The flap made in the second stage of the operation is now turned inwards upon the hinge, so to speak, formed by its attachment to the margin of the palatal processes of the superior maxilla and palate bone, and is fixed in this position (so as partly to bridge across the cleft) by two moderately fine catgut sutures passed through its edge and the thin strip of mucous membrane which was left *in situ* on the opposite side of the cleft, internally to the triangular flap (Fig. 280).

Fourth Stage.—The apex of the triangular flap is now carried across the cleft, and the anterior part of its inner margin is attached by means of two or three silver sutures to the outer border of the incision upon the other side of the palate (Fig. 280). If there is any difficulty in carrying the triangular flap across the cleft, it may be necessary to detach its base more freely from the soft parts which connect it with the back of the hard palate. It will usually be found that the triangular flap lies very loosely in its new position, but no fear need be entertained that on this account it will fail to unite. The upward pressure of the

tongue will constantly maintain the raw surface, which forms the upper portion of the flap, in close contact with the raw surface, which, if the third stage has been properly carried out, is directed downwards so as to form a bed for its reception.

The subsequent treatment of the case is in no wise different from that after the ordinary operation.

Comment.—The advantages claimed for this measure are these :—1, There is less hæmorrhage ; 2, less bruising of the parts ; 3, less sacrifice of tissue ; 4, less tension upon the flaps ; 5, the operation can be easily performed at an early stage—e.g. between the ages of one and two years.

The disadvantages are :—1, The hard palate alone is united ; 2, a foramen is apt to be left in the front part of the cleft. (This can be closed later.)

The late Mr. Davies-Colley recommended the operation in the cases of infants ; in cases where the usual operation has failed ; and where the gap is too wide to be bridged over by the usual operation.

Mr. Davies-Colley did not advise or practise his flap method of operating for all cases of cleft palate ; indeed Mr. Jacobson notes that in 1899 he had tended more and more to perform the old operation. The original and valuable points in Mr. Colley's work were mainly two—first he showed that where the tissues of the palate are thin and delicate as in young infants, success might be obtained by superposing two flaps, and hence that the operation might be performed at an earlier age than is customary ; secondly that when the gap is very wide, and the usual operation might be expected to fail entirely, a modified degree of success could be obtained by the flap method.

This reasoning appears to be thoroughly sound. Mr. W. A. Lane has adopted Mr. Davies-Colley's method and views, and goes still further in urging that some form of flap operation should be done in all cases soon after birth. "The best time for operation is the day after birth, or as soon after that as possible" (W. A. Lane, "Cleft Palate and Hare-Lip," 1905, page 421).

It would not be fair to Mr. Lane's work to attempt an epitome of his many elaborate methods of cutting the flaps, which he takes from the covering of the alveolar margin as well as the hard and soft palate.

No fewer than eighteen figures are used to illustrate the subject in the "Operations of Surgery" by Messrs. Jacobson and Rowlands, but even with the long descriptions appended, the reader will probably be much at a loss to understand the technique.

It must suffice to say that in cutting the flaps no special regard seems to be paid to their blood supply, that the flaps are made of all possible shapes, according to the form of the cleft, etc., and that superposition of the flaps is often though not always performed. In operations on cleft palate the tissues should be treated with all possible gentleness, and for this reason the needles employed should be as small as is convenient. Especially should this be the case when operating on young infants, and Mr. Lane employs short straight and curved needles held in a special holder.

We have had no personal experience of these flap-operations undertaken at a very early period of life, and will therefore express no opinion as to their merits compared with the usual method. It should be remembered that even in the hands of those who specially advocate this method two or more separate operations may be required in any individual case, and Mr. Lane calls attention to this fact.

Nor is the operation by the older method performed at a later period, say three years, free from this objection. It is not very infrequent for union to occur along two-thirds of the line, and for the remainder to require a second operation.

If the cleft has been an extensive one it frequently happens that a small aperture is left, especially near the alveolar border, or at the junction of the hard and soft palate. These small openings usually close in time without a second operation being necessary.

The worst result is, of course, the whole wound becoming septic, and the stitches cutting right through. As Mr. Edmund Owen has pointed out, it is then possible to obtain union by paring the edges and introducing fresh sutures at the end of twelve or fourteen days after the first operation.

Brophy's Method (wiring and approximation of the superior maxillæ).—As mentioned already, in 1904 Brophy of Chicago brought forward a wholly novel proposal with regard to the operative treatment of cleft palate. The two maxillæ are forced

together by means of silver wire, two threads of which are drawn through the bones from side to side, and tightened up over leaden plates. The operation can only be done if the patient is under three months of age.

The wire may be introduced by means of a pilot thread of stout silk mounted on a strong curved needle on a handle. The position of the wires will be understood from Fig. 281.

It will probably be found that tightening up the wires—even combined with vigorous lateral pressure made by the surgeon's fingers—has but little or no effect upon the cleft. It will then be necessary to divide the mucous membrane high up—just over the molar process—and to cut through the soft bone transversely. Thus a transverse fracture is secured in each maxilla, the lower part of which bone can be pressed inwards so that the two touch each other. The edges of the cleft may be pared and sutures introduced before the wires are tightened, but usually a later suturing operation has been performed. In fact, in one case of Brophy's operation, which Mr. Edmund Owen performed and recorded as successful, no fewer than four subsequent operations were required to finish the closure of the cleft !

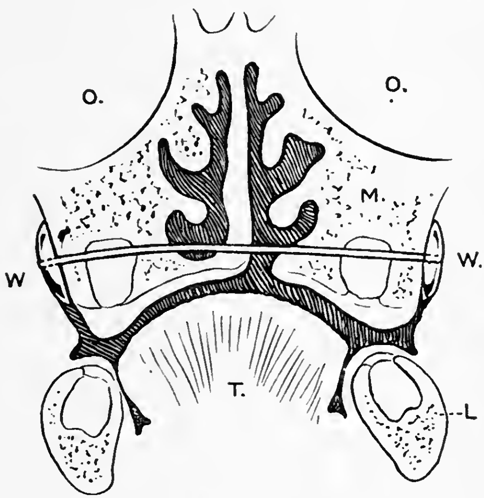

FIG. 281.—BROPHY'S METHOD OF WIRING FOR CLEFT PALATE.

O, Orbital cavity; M, Upper jaw; L, Lower jaw; T, Tongue; W, W, Silver wire (note its relation to the teeth-sacs, which must be damaged).

The wires, when tightened up, are left in place for a variable time; about three weeks seems to be the average. An anæsthetic will be required for their removal. If they irritate they must be removed promptly, for necrosis has followed and might be a terribly grave complication.

Comment.—It has been impossible to omit reference to this

method of wiring and forcible fracture, but we must express our opinion that it is not an operation that will stand the test of time. The following arguments against it should be considered before it is undertaken :—

1. It is based on an illogical view of the pathology of cleft palate. The two parts of bone in a child with this deformity *are not abnormally separated*, and in many cases the alveolar border is intact. If the jaws are closed the alveoli come in contact. Hence to narrow the cleft by forcing the maxillæ together will result in adding a deformity in after life which may give trouble to the patient in mastication.

2. The operation is a very rough one to perform on a young infant, and especially on parts of such importance as the developing upper jaws, which, of course, at that age are packed with rudimentary teeth. The passage of two stout silver wires across both bones, the fractures made with the knife, etc., and the pressure applied can hardly fail to have a bad effect upon the teeth and their nerve supply. In fact the dental nerves must be actually cut or torn across.

3. The severity of the operation has led to a considerable mortality. We have personally heard of several disasters. Mr. James Berry (*Brit. Med. Journ.*, Oct. 7, 1905) states that of 11 cases operated on by Brophy's method in this country, no less than 5 of the patients died as a result ! In another of the series necrosis of the bones followed, though the child recovered.

A single death from a cleft palate operation is a surgical disaster. What can be said of a method causing a mortality of 50 per cent. ?

AFTER-TREATMENT IN CLEFT PALATE OPERATIONS

No food of any kind should be administered to the patient until all vomiting has ceased. The diet should be simple, and may consist for the first day of milk or milk-and-water only, and after that of beef-tea, broth, eggs, arrowroot, custard pudding, bread-and-milk, stewed fruit, and the like. Two mistakes are frequently made in the after-treatment : one is to starve the patient, and the other is to feed him so frequently with small quantities of food that the pharyngeal muscles are never at rest.

One author, indeed, says that food should be administered "unceasingly."

The patient should be fed as an ordinary patient is fed, but the food must be fluid, or at least perfectly soft, and must be swallowed slowly and carefully. The pharyngeal muscles contract more completely around a small bolus than a large. This simple and almost fluid diet should be observed for two or three weeks, until, indeed, it is clear that the wound has healed, or has broken down hopelessly.

It is well to forbid much talking. For the first few days the less the patient speaks the better.

One important factor must not be overlooked—the mouth must be kept clean. It is often rendered foul by decomposing milk and beef-tea, which remain in the recesses of the mouth, and hence the nurse must see to the gentle cleansing of the mouth after every meal.

Sprays of antiseptic lotion are, however, not to be advised; they are apt to bring on coughing or retching, and thus lead to failure of union in the wound. The best mouth-wash is a very weak boric or carbolic solution. If the patient is very young it will be necessary to secure the hands for a few days.

Constant attention on the part of the nurse will be required to prevent the child from fretting, etc., and few surgical cases tax the nurse's patience so much.

The sutures may be removed, as a rule, from eight to fourteen days after operation. The longer they can be left the better.

The parents must be urged to take pains in educating the child's articulation, especially in the clear pronunciation of dental and sibilant sounds. Without long practice and care a perfect surgical success may issue in a very poor vocal result.

CHAPTER V

TRACHEOTOMY AND LARYNGOTOMY

I. Tracheotomy

Anatomical Points.—The trachea in the adult is about four and a half inches in length. It is surrounded by an atmosphere of lax connective tissue, which allows a considerable degree of mobility to the tube. The mobility of the trachea is greater in children than in adults. The length of the trachea in the neck is not so considerable as may at first sight appear, and, according to Holden, not more than seven or eight of the tracheal rings (which number sixteen to twenty in all) are to be found above the manubrium sterni. The distance between the cricoid cartilage and the sternal notch varies greatly, and depends upon the length of the neck, the age of the patient, and the position of the head.

If two inches of the trachea are exposed above the sternum when the head is erect, then in full extension three-quarters of an inch more of the windpipe will, as it were, be drawn up into the neck. According to Tillaux, the average full distance between the cricoid cartilage and the sternum is in the adult about two and three-quarter nches (7 cm.). The full distance in a child between three and five years is about one inch and a half (4 cm.); in a child between six and seven, about two inches (5 cm.); and in children between eight and ten years, about two inches and a quarter (6 cm.). The effects of growth, and of the position of the head, upon the position of the cricoid cartilage have been shown by Symington in his work on the "Anatomy of the Child." In a child about two years of age the lower border of the cricoid cartilage is opposite the upper border of the sixth cervical vertebra when the head is acutely flexed, and opposite the upper border of the fifth vertebra when it is extended. At birth the lower border of the cricoid cartilage corresponds with the lower border of the fourth cervical vertebra, between the age of six and twelve months it is opposite to the upper border of the fifth vertebra

at five years it corresponds to the upper border of the sixth vertebra' and in the adult to the upper border of the seventh.

Symington confirms the statement by Allan Burns that in a child twelve months old the distance from the hyoid bone to the sternum is equal to the breadth of three fingers; and if these be placed in front of the neck, one finger would cover the larynx, half a finger the isthmus of the thyroid body, and a finger and a half the space between the thyroid body and the sternum; while if the head be extended, the latter space would be increased to the breadth of two fingers.

With regard to the diameter of the trachea, and the size of the tube, the following table is founded upon the observations of Symington and Guersant. (*See* Fig. 282.)

AGE	DIAMETER OF TUBE
Under 18 months	4 mm.
$1\frac{1}{2}$ to 2 years	5 mm.
2 years to 4 years	6 mm.
4 years to 8 years	8 mm.
8 years to 12 years	10 mm.
12 years to 15 years	12 mm.
Adults	12 mm. to 15 mm.

These measurements refer to the internal diameter of the trachea, and are of practical value since they correspond to the full size of the tube used for tracheotomy at any particular age. It should be noted, however, that, as M. Tillaux pointed out in his valuable "Anatomie Topographique" (page 416), striking differences are found in the tracheal dimensions in different subjects of the same age. Hence the measurements given above, which should be compared with Fig. 282, must not be considered as more than approximate. The tracheal lumen is not perfectly circular, the posterior part, completed by membrane, being flattened. The incomplete ring formed by the cartilages is longer in the antero-posterior than the transverse diameter.

The *relations of the trachea* are considered in the section which follows.

The Site of the Operation.—The operation is said to be "high" or "low" according as the trachea is opened above or

below the isthmus of the thyroid body (V and VI, Fig. 283). In the adult the isthmus crosses the second and third rings of the trachea, and sometimes even the fourth. In the child the isthmus is narrow, and is usually somewhat higher up; it may even lie on the crico-tracheal membrane. The high operation is always to be preferred; of the low, only a brief description will be given.

In cutting down upon the trachea in the middle line of the neck, from the cricoid cartilage to the sternum, the following parts are met with: Beneath the skin lies the subcutaneous fatty layer, which varies greatly in thickness. If very thick, it may be a cause of trouble in performing tracheotomy. Next comes the anterior or most superficial layer of cervical fascia, which is separated from the middle layer in the lower part of the neck by a cellular interval, but higher up the two layers practically blend. The anterior jugular veins lie mainly superficially to the fascia. As a rule these veins are some little way apart on each side of the median line, and do not communicate except by a large transverse branch which lies in the interfascial space at the upper border of the sternum. Sometimes there are many communicating branches in front of the tracheotomy district, or the veins may form almost a plexus in front of the trachea, or there may be a single vein which will follow the middle line. Then comes the middle layer of the cervical fascia, enclosing the sterno-hyoid and sterno-thyroid muscles. Above the isthmus a transverse communicating branch between the superior thyroid veins is sometimes found. Abnormal branches of the superior thyroid artery may cross the upper rings of the trachea. Over the isthmus is a small venous plexus, from which the inferior thyroid veins arise; while below the isthmus these veins lie in front of the trachea, together with the thyroidea ima artery (when it exists). The inferior thyroid vein may be represented by a single trunk occupying the middle line.

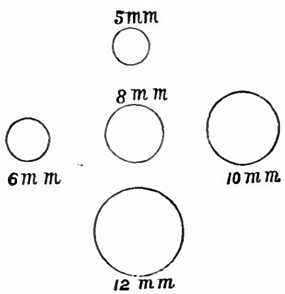

FIG. 282.—SECTIONS OF TRACHEOTOMY TUBES: SHOWING THE EXACT DIAMETERS, EXPRESSED IN MILLIMETRES.

In the infant before the age of two years the thymus extends up for a variable distance in front of the trachea. At the very root of the neck the trachea is crossed by the innominate and left carotid arteries, and by the left innominate vein.

Advantages of the High Operation.—The anterior jugular veins are smaller here, and transverse branches are rare.

The muscles which are in close contact below diverge a little as they ascend. The great vessels are not in danger, the inferior thyroid vessels and the thyroidea ima are avoided.

The trachea is nearer the surface, is more fixed, and is much more readily exposed.

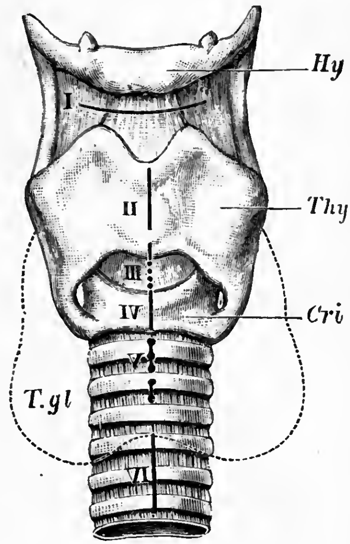

FIG. 283.—OPERATIONS ON THE LARYNX AND TRACHEA. (*Tillmans.*)

I, Subhyoid pharyngotomy; II, Thyrotomy; III, Laryngotomy; IV, Cricotomy; V and VI, High and low tracheotomy; *Hy*, Hyoid bone; *Thy*, Thyroid cart.; *Cri*, Cricoid cart.; *T.gl*, Thyroid gland.

Disadvantages of the Low Operation.—The anterior jugular veins are larger, and transverse branches are common.

The muscles are in closer contact. The inferior thyroid veins and thyroidea ima are readily wounded. The great vessels and the thymus may be exposed to danger.

The trachea is much deeper, is more mobile, and is exposed with difficulty.

To these disadvantages Mr. Jacobson adds the following objections:—In the low operation (1) pus is more easily conducted into the mediastina; (2) broncho-pneumonia is more probable when the wound is low down in the trachea; (3) the suction action of the chest can more readily draw the tube into the wound when the incision is near to the thorax.

FIG. 284.—HOOK USED FOR DRAWING DOWNWARDS THE THYROID GLAND IN TRACHEOTOMY, ETC.

Instruments required.—Scalpels; dissecting, dressing, and

Wells' pressure forceps; toothed forceps; sharp hook; blunt hook; scissors; needles; tracheotomy tubes and tapes. To these may be added a gag and tongue forceps, small wound retractors, and sterilised feathers to clear the tube when first introduced. A pair of dressing forceps has been mentioned, as it may be required to dilate the tracheal opening. Special curved dilators are sometimes employed.

FIG. 285.—DURHAM'S ANGULAR TRACHEOTOMY CANNULA.

A good tracheotomy tube should be of simple construction, should be easy to introduce, should be as large as the diameter of the trachea will admit, should lie exactly in the long axis of the windpipe without touching the tracheal wall with its extremity, should have a movable shield so that it is disturbed as little as possible, and the inner cannula should be capable of being easily inserted and removed.

Mr. Durham's well-known tubes (Fig. 285) are in all respects admirable, but care must be taken that no segment of the lobster-tail cannula is loose.

HIGH TRACHEOTOMY

The patient is anæsthetised with chloroform. This anæsthetic is certainly the most convenient, and, provided that as little as possible is used, and that the operator is prepared to work with due promptness and rapidity, the danger from the

anæsthetic will be slight. In adults, and occasionally in children, local analgesia by eucain (with or without adrenalin) may be preferred. Many surgeons have a small quantity of chloroform administered and then inject eucain or cocain solutions. One drawback to local anæsthesia is the resulting swelling of the tissues, which masks the anatomy of the part.

It should not be forgotten that a considerable proportion of the deaths from chloroform have occurred during the performance of tracheotomy, and hence great care should be taken in its administration. Ether alone is not advisable, as it may increase venous congestion of the neck, and is too slow, but the A.C.E. mixture, or one of chloroform one part and ether two parts, may be safely employed.

1. **Position of the Patient.**—The child is enveloped in a thin macintosh sheet, and is placed close to the right edge of the table. The surgeon stands by the same side of the table. The neck is supported on a firm sand-bag, or pillow, of suitable size. When the child is ready the head should be drawn well over the upper end of the table, so that the vertex is turned nearly towards the ground.

The sand-bag, or pillow, will be placed close to the upper edge of the table, and over it the child's head is extended in this extreme manner.

This position renders the structures on the front of the neck tense, steadies the trachea, draws as much of that tube up into the neck as is possible, and brings it a little nearer to the surface. The superficial veins are, moreover, a little emptied of their blood by this attitude of over-extension.

FIG. 286. TRACHEOTOMY HOOK.

It need hardly be said that if the operation is performed at night time a good light should be obtained. An electric head-lamp will be found useful.

The anæsthetist stands at the head of the table, and the important duty should be imposed upon him of holding the head steady, and of keeping the chin most rigidly in a line with

the sternal notch. If the head be allowed to fall over to one or other side, the position of the middle line is lost.

An assistant stands by the side of the anæsthetist, and will, later, take charge of the sharp hook (Fig. 286).

A second assistant, with sponges, etc., will take his place to the left of the table—*i.e.* to the surgeon's right.

2. **Exposing the Trachea.**—An incision is made with a sharp scalpel very precisely in the median line of the neck. Its length will be about an inch or an inch and a half, and its upper extremity will be at the upper border of the cricoid cartilage. Before making this cut, the surgeon should have accurately defined the position of the thyroid and cricoid cartilages. The latter cartilage is often difficult to detect in stout subjects, and especially in young infants.

The skin and the trachea are steadied with the left hand while the cut is being made.

The right hand must be unsupported. If the operator rests his wrist upon the upper part of the child's chest, as he is tempted to do, he will find that the rapid movements of the thorax in laboured breathing render that part no proper place for support.

The surgeon, still fixing the trachea and soft parts with the left hand, cuts deliberately in the middle line through the subcutaneous fat and the anterior layer of the cervical fascia. The sterno-hyoid and sterno-thyroid muscles are reached, and the interval between them is opened up. All this is done by successive clean cuts.

The surgeon now separates the muscles, using the dissecting forceps and the handle of the scalpel for the purpose.

Keeping still to the middle line, and once more steadying the trachea, he divides cleanly, and by cautious cuts, the fascia covering that tube.

If the assistant can be relied upon to retract evenly, help will be obtained from him. The form of retractor that takes up least room and that cannot slip is a suture passed through skin and fascia, etc. The loop of suture-retractor on each side is held in Wells' forceps, and even traction made outwards. Metal retractors are apt to slip, and may be positively dangerous, as the assistant may conceal and displace the trachea with one of them.

At this stage veins will probably be encountered, and may be displaced to one or other side by the handle of the scalpel. The isthmus of the thyroid will be seen, and is by a like means displaced downwards. If necessary, it may be drawn and held downwards by a small blunt hook.

The surgeon next feels for the tracheal rings with his left forefinger. He should be satisfied that the tube is well bared, and he should be able to see the white rings themselves.

3. **Opening the Trachea.**—A small sharp hook is now introduced into the cricoid cartilage, and is given to the assistant to hold who stands at the head of the table.

The hook is kept precisely in the middle line, and is used to fix and draw forwards the cricoid cartilage, and to render the trachea tense. The assistant must give a little play to the hook as the larynx moves with each inspiration.

With the left forefinger the operator feels the upper rings of the trachea, and with a slender scalpel, held with the edge towards the patient's chin, he stabs the trachea in the median line some three rings below the cricoid, and cuts up on to the hook (v, Fig. 283).

The noisy rush of air entering and escaping through the wound, the coughing of the child, and the expulsion of mucus and membrane bring about a moment of confusion. The hook must not be removed. It remains as an easy guide to the median line of the trachea and the site of the opening therein. The opening must be free.

If the hook be not used, the operator may miss the slit in the trachea he has already made, and may, in his haste, proceed to make another.

4. **Introduction of the Tube.**—The right margin of the cut in the trachea should be lightly seized with the toothed forceps, which are held in the left hand; and while the opening is thus for a moment demonstrated and fixed, the tube and pilot are slipped in. If the forceps be employed as directed, the tube can be introduced with certainty and ease. If no such precaution be taken, much time may be wasted in driving the pilot hither and thither in search of the slit-like opening, which is very easily lost. The depth of the wound, the quantity of blood and mucus which may fill it, and the movements of the trachea

may readily cause the site of the opening to be lost, especially if the trachea has not been well exposed and the fascia freely divided. Provided that the trachea has been incised and the sharp hook is still in place, dressing forceps or the special curved dilator with separating blades will readily enable the tube to be introduced in case of difficulty. This is, of course, supposing the vertical incision in the tracheal wall has been made long enough.

It is most important not to incise the trachea in two separate places.

It will usually be found more convenient to restore the child's head to the erect position before the tube is introduced. When the tube is in place—and not before—the sharp hook is removed.

The tube is secured in place by tape, and the wound below

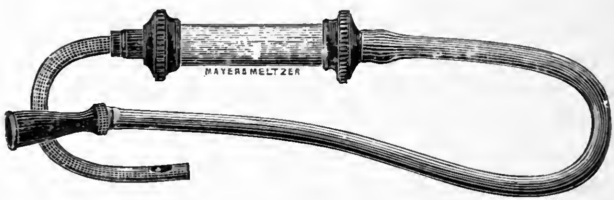

FIG. 287.—PARKER'S TRACHEAL ASPIRATOR.

the tube is brought together by a suture or two of silkworm gut. A piece of lint properly shaped and smeared with boric acid or carbolic oil is placed under the shield of the tube, and is made to cover and protect the wound.

Each end of the wound will probably require one or two silkworm-gut sutures to approximate the edges.

Rapid and efficient sponging with small pieces of fine Turkey sponge is of great service throughout the operation.

5. **Detachment of Diphtheritic Membrane.**—Before the tube is inserted an attempt may be made in all cases of diphtheria to rid the trachea of false membranes and retained secretions.

A moistened feather is passed into the windpipe and rotated so as to detach any false membrane and to draw it out. As a rule, however, the urgent necessity of introducing the tube makes it advisable to effect this clearing with feathers passed through

the latter. Harm may be done by too vigorous use of the feathers.

A special suction aspirator, devised by Mr. R. W. Parker (Fig. 287), is sometimes employed for removing pieces of membrane, but the surgeon may not have it to hand at the time of operation, and he may even be impelled to suck out the fragments into his mouth. The dangers of this practice need not be pointed out, and although one may admire the courage that inspires it, the risk is too serious to be advised.

When the trachea has been opened, and after the tube has been inserted, care should be taken lest particles of membrane are coughed into the operator's face. Infection with diphtheria in this manner has occurred many times. The assistant's sponges held a short distance in front of the wound should guard against this accident.

TRACHEOTOMY BY BOSE'S METHOD

This method—often termed the bloodless method—is extensively practised in Germany.

A vertical incision is made in the median line. It commences opposite the centre of the thyroid cartilage, and is continued downwards for about one and a half or two inches. The incision is carried down to the lower part of the thyroid cartilage and the upper part of the cricoid. The soft parts being held aside by retractors, a transverse incision is made along the upper border of the cricoid cartilage in such a way as to divide the layer of the deep cervical fascia which lies in front of the trachea and which holds the thyroid isthmus. A blunt director is now introduced through this transverse incision, and by its means the fascia and the isthmus, together with all the veins connected therewith, are fully separated from the trachea. A broad, curved hook (Fig. 284) is now introduced, and the detached fascia, together with the other soft parts, is drawn downwards, leaving the trachea quite bare. The cricoid cartilage is now fixed by means of a double-pointed sharp hook, and the tracheal rings are incised in the usual way.

This method has much to commend it. It is simple and easy of performance. It involves some expenditure of time, and some damage may be done to adjacent structures by the

director if care be not used. Veins are readily torn through by this instrument. If cautiously performed, the operation has distinct claims to be called "bloodless."

Probably most surgeons in performing tracheotomy, provided extreme rapidity of execution is not urgently demanded, use some form of blunt dissection in clearing the front of the trachea. This may be effected either by the dissector, the blunt-pointed "dissector," or a raspatory (as recommended by Mr. Whitehead). The special point of Bose's method just described consists in the *transverse* division of the fascia over the cricoid cartilage, with subsequent downward detachment of it and of the isthmus. It may be noted that the isthmus of the thyroid gland is itself not very vascular, and that partial or complete division of the isthmus has often happened without harm resulting. It seems to us that a clean vertical incision down to the trachea, aided by lateral detachment of fascia, and muscles, etc., by blunt dissection on either side, is the best. If the thyroid isthmus comes in the way it may be pushed down or partially divided.

Comment.—Tracheotomy, as here described, has been considered in connection with its most common surroundings—namely, with the operation urgent, and the patient a young child struggling against suffocation.

As an operation, tracheotomy must be regarded as an easy and simple procedure. Those who have performed it only upon the dead subject must be at a loss to understand the terrible possibilities with which the introduction of a tracheotomy tube appears to be surrounded. In the adult, it is true, the operation is but rarely in any way difficult or complicated; in an infant with a short stout neck, on the other hand, it may be attended with not inconsiderable difficulties.

For the accidents which so often occur during tracheotomy the hurry and the excitement of the operation and the fear that the child is ceasing to breathe are in the main answerable, and not the anatomical conditions of the operation itself.

Tracheotomy affords a striking illustration of the adage, "The more haste the less speed." The surgeon who proceeds to open the trachea in a precise and deliberate way will have completed the operation before the frantic man who, with

palpitating heart and a trembling hand, cuts wildly towards the spine, and who appears to be actuated by the unsteady conviction that he must gash something or the child will perish. Artificial respiration may be relied upon to restore a patient who has ceased to breathe for some seconds, provided that the tube has been introduced without complication, and that the cessation of respiration does not depend upon uncontrollable conditions. The operation must be systematically done. The surgeon who seeks to be brilliant at this operation may be at once regarded as dangerous.

A child's trachea is very mobile, and it is marvellous to note the ease with which it may be made to collapse on pressure. To the finger roughly introduced the infant's trachea offers little resistance, and its mobility is such that it has been held aside unknowingly by retractors while the operator is scoring the œsophagus (Durham).

The tracheal rings are very soft, and with a sharp scalpel little force is required to divide them.

It is important that the incision of the trachea should be exactly placed in the middle line, should not be too deep a gash, and should be of sufficient length to correspond with the diameter of the tube to be inserted. A too short opening, still more a mere puncture, is certain to embarrass the operator, as the attempt to enlarge it later may lead to a double opening being made.

In young infants, and in children generally, care should be taken that the cricoid cartilage is not severed. If it be divided, the tube is found to be placed so near to the larynx as to produce undue irritation of that organ.

In children the isthmus of the thyroid body is small, may be disregarded, and may be safely divided if the section be in the median line. In adults it is readily recognised, and easily drawn downwards out of danger.

It must be expected that in some cases there will be free venous bleeding. While it is well that the hæmorrhage should be checked before the tube is introduced, lest blood find its way into the lung, yet too long a time should not be devoted to attempting to secure the vessels. As soon as the tube is introduced, air enters the lung more freely, the right side of the

heart is relieved, and venous bleeding, which before was very copious, ceases almost immediately.

Serious hæmorrhage in the high operation can hardly occur except from puncture of important vessels *at the side* of the trachea. Careful exposure of the latter in the middle line will avoid this risk.

In low tracheotomy the danger of severe hæmorrhage is far greater.

The cervical fascia must be well and cleanly divided. The tube has many a time been introduced between the trachea and the imperfectly divided fascia, the operator being under the impression that it has been inserted into the windpipe. No air, however, escapes.

In cases where an extensive membrane exists, it may escape division when the trachea is opened, and the tube may then be inserted between the membrane and the tracheal wall. In this case, also, no air escapes from the instrument.

In most cases of tracheotomy performed by a novice, or carried out with undue haste, it will be observed that more time is taken up in introducing the tube than in finding and incising the trachea.

Some General Rules in Tracheotomy.—1. Let the chin be kept rigidly in a line with the sternal notch.

2. Cut only in the middle line.

3. If retractors are used, be sure that the assistant retracts evenly from the middle line with them.

4. See the white rings of the trachea, and feel them bare before plunging the knife into the windpipe.

5. Avoid hurry.

LOW TRACHEOTOMY

This term is usually applied when the opening is made into the trachea below the isthmus of the thyroid. It is, as we have said, a far more difficult operation than the high one, because of the depth of the trachea from the surface, and on account of the large vessels in its close proximity. These are chiefly—

1. The inferior thyroid veins, which lie over or close to the middle line, and as a rule in the left innominate. Their arrangement is very variable, but there is nearly always a venous plexus

in front of the trachea which, if distended, may cause great trouble to the operator.

2. The left innominate vein crossing obliquely from left to right behind the upper border of the sternum. It varies in height, and may even touch the isthmus.

3. The innominate and left common carotid arteries overlap the trachea, and an abnormal thyroidea ima artery (a branch of the innominate or arch of the aorta, etc.) is not infrequently present.

4. A transverse vein lies at the lower border of the thyroid isthmus—it varies greatly in size.

As regards the depth of the trachea from the surface just above the sternum, the normal distance of 1½ inches (4 cm.) may be increased in cases of tumour of the thyroid gland to 3 inches (8 cm.), or even more.

Apart from these difficulties, and others mentioned on page 179, it must be noted that the condition calling for low tracheotomy may readily displace the trachea from the middle line. This adds to the trouble both of finding the trachea during the operation and of replacing the tube subsequently, etc.

Low tracheotomy is rarely performed except for obstruction due to a growth in the neck, usually a thyroid tumour.

The Operation.—The special points are mainly the following:

1. Be provided with sufficiently long tubes—vulcanite and silver—with sliding shields. The ordinary tracheotomy tubes, with short curves or of angular form, will probably be useless, as they will not reach the trachea. Unless the tube fits properly it may slip out and cause the patient's death.

2. Have the patient's neck well put on the stretch, and the head kept exactly in the median line. Retractors are essential, but sutures may be used (*see* page 182).

3. The dissection being carried down through the deep cervical fascia, and all veins drawn aside if possible (divided between two ligatures if not), the lower border of the thyroid isthmus is looked for and drawn upwards by a hook with the transverse vein.

4. The possible lateral deviation of the trachea should be borne in mind. When it is exposed and seized by a sharp hook, its

depth from the surface should be estimated and the suitable tube selected.

5. In incising the trachea great care should be taken lest the knife touch the overlying veins, which must be guarded by the assistant's retractor.

6. An electric head-lamp may be of the greatest value.

AFTER-TREATMENT

This will obviously depend a great deal upon the nature of the case. The after-treatment of a case of tracheotomy performed for impacted foreign body will of necessity differ greatly from that performed for diphtheria. The period at which the tube has to be removed can never be decided in an arbitrary manner. *It should be taken out at the earliest possible period.* In a case of œdema of the glottis from scald it may be possible to discontinue it at the end of twenty-four hours, while when tracheotomy has been performed for a laryngeal growth the tube may have to be worn during the remainder of the patient's life.

In a child, the sooner the rigid metallic cannula can be replaced by an indiarubber tube the better, especially if it be necessary to keep the tracheal sinus open for a prolonged period.

There is often much difficulty with children in getting them to take sufficient food; and if this difficulty be not readily overcome, it is well that the child should be fed, for a while, by means of a small Jacques' catheter passed down into the œsophagus through the nose.

With regard to the steam tent, or "croup bed," and the measures to be adopted to keep the tube clean, we cannot do better than quote the practical observations of Mr. Jacobson :—

"While fully aware of the need of moisture when the atmosphere is dry, when the membrane tends to crust and become fixed, I am of opinion that the unvarying rule of cot-tenting and use of steam is disadvantageous. The weakly condition of children with membranous laryngitis, and all they have gone through, must be remembered. Believing that such seclusion, and so little admission of air, tend to increase the asthenia, and any tendency to sepsis, I much prefer to be content to keep off draughts by a screen, which allows of the escape of vitiated air above, using steam, if needful, according

to the size of the room, fireplace, etc., and according to the kind of expectoration, whether easily brought up by the cough or feathers, or viscid, quickly drying, and causing whistling breathing. If the temperature can be otherwise kept up to 60° or 65°, I much prefer to use a thin flat sponge, often wrung out in a warm solution of boracic acid. The inner tube must be frequently removed and cleansed every hour or two at first. If the secretions dry on and cling to it, they are best removed by the soda solution mentioned below. At varying intervals between the removals of the tube, any membrane, etc., which is blocking it, appearing for a moment at its mouth and then sucked back, must be got rid of by inserting narrow pheasant feathers and twisting them round before removing them. If the exudation is slight, moist, and easily brought up by cough or feather, sponging or brushing out the trachea is not called for, but should be made use of when there is much flapping, clicking, or whistling of the breathing; and if this is harsh, dry, or noisy, instead of moist and noiseless, two of the best solutions are sodæ bicarb. gr. v-xx to aq. ℥j, or a saturated one of borax with soda. These may be applied by a hand or steam spray over the cannula for five or ten minutes at a time, at intervals varying according to the relief which is given, or applied with a laryngeal brush, feather, or bit of sponge twisted securely into a loop of wire. When any of these are used, the risk of excoriation and bleeding, and the fact that only the trachea and large bronchi can be cleaned, must be borne in mind; and with regard to manipulations for cleansing the trachea and removing the inner tube, it is most important to remember that the caretaking may be overdone, and a weakly child still further exhausted by meddlesome interference."

It has already been stated that the tube should be removed as early as possible, say after the fourth day. If it cannot be then dispensed with, a rubber tube should be inserted instead of the metal one. This rubber tube may be shortened from time to time, and should be tentatively removed after a week or two. "The longest possible period for the formation of membrane is about ten days."

Difficulty in doing away with the use of the tube rarely depends upon a mechanical cause.

A simple measure consists in inserting a tube with an aperture in its convexity, so that air can pass through the larynx; the other opening may be plugged for a time. If the child then breathes well, it will be safe to remove the tube entirely.

In the worst cases Macewen's tube (a gum-elastic one with bevelled opening) should be introduced, under chloroform, from the tracheal wound up through the mouth, the lower end being of course placed in the trachea below the wound. The child's hands should be secured to prevent its pulling at the tube, the upper end of which is guarded by a sheath of rubber, to prevent its being bitten through. The end is secured by tapes passed round the head. Macewen's tube may be left in from twelve to eighteen hours.

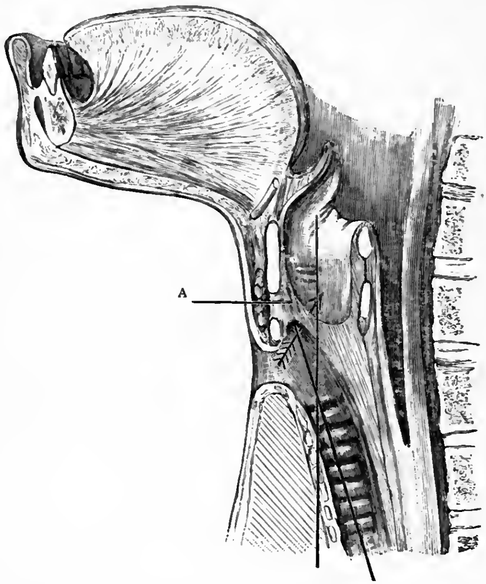

FIG. 288.—DIAGRAM OF THE CONDITIONS FOUND IN A CHILD WHO HAD WORN A TRACHEOTOMY TUBE FOR MORE THAN THREE YEARS, AND WHO WAS CURED BY REMOVAL OF THE CICATRICIAL TISSUE AND SUBSEQUENT INTUBATION.

A, Cicatricial tissue nearly blocking the lower aperture of the larynx. The lines show the alteration in the axis of the trachea. The arrow marks the lumen of the cicatricial diaphragm.

The metal intubation tubes (O'Dwyer's) may be left in much longer, and are preferred by many surgeons. Their drawback is that the child is apt to cough them up. They are, of course, introduced from above, whilst Macewen's tube is inserted from below.

Ehrhardt (*Arch. für klin. Chir.*, 1903) records five cases of the successful use of intubation on children with "stenosis" following tracheotomy.

II. Laryngotomy

Laryngotomy, or the artificial opening of the larynx through the crico-thyroid membrane, is occasionally performed as a substitute for tracheotomy. The operation has the advantage of being very rapidly and very easily carried out. It is quite

inapplicable to children under thirteen years of age, owing to the narrowness of the crico-thyroid space. The great drawbacks of the operation are the proximity of the vocal cords and the difficulty of adjusting a suitable tube. Laryngotomy is totally unsuited for cases in which a tube has to be long worn.

The vertical height of the crico-thyroid space in the well-developed adult subject is only about half an inch.

The crico-thyroid arteries cross the space, but are usually of quite insignificant size. Occasionally they are large, and Mr. Durham states that "cases are recorded in which serious and even fatal hæmorrhage has occurred from these vessels."

For the general surroundings of the operation, the instruments required, the special precautions to be taken, and the after-treatment, the reader is referred to the section on Tracheotomy.

The Operation.—The head is well extended over a sand-bag or hard cushion, and is kept fixed, with the chin in a line with the sternal notch. The anæsthetic selected is chloroform. The anatomical details of the part must be made out, and the crico-thyroid space defined (III, Fig. 283).

The larynx is lightly steadied with the left hand, while the surgeon makes a vertical median incision, about an inch and a quarter long, over the lower part of the thyroid cartilage, the crico-thyroid space, and the cricoid. The fascia having been divided, the interval between the sterno-thyroid and crico-thyroid muscles is appreciated, and is widened with the handle of the scalpel.

The crico-thyroid membrane is exposed, and is divided horizontally, just above the cricoid cartilage.

Care must be taken that the air-passage is well opened, as it is not difficult to pass the tube downwards between the crico-thyroid membrane and the mucous lining of the windpipe.

The laryngotomy tube is shorter than that used for tracheotomy, and is oval on section.

Some surgeons advise that the membrane be opened by a vertical incision, on the grounds that the operation can, if desired, be extended by dividing the cricoid cartilage, and that in the horizontal incision damage is usually inflicted upon the crico-

thyroid muscles, and possibly also upon the lateral crico-arytenoid muscles.

A crucial incision of the membrane may be employed, and this should always give room for the tube, without risk of damaging the muscles.

Suprathyroid Laryngotomy.—This operation, which is sometimes called subhyoid pharyngotomy, has been on a few occasions employed for the removal of growths situated at the upper opening of the larynx, and particularly of such as are connected with the epiglottis. The operation is simple, but even in the adult it rarely affords sufficient access for the efficient use of instruments (I, Fig. 283).

Solis-Cohen (Ashhurst's "Encyclopædia of Surgery," vol. v., page 735) has collected six examples of the operation for the removal of tumour. Three of these died within a few days of the operation.

A transverse incision is made through the thyro-hyoid membrane, parallel and close to the lower border of the hyoid bone. The skin, the fascia, the sterno-hyoid muscles (in whole or in part), the thyro-hyoid membrane, and the mucous membrane are divided in order.

The epiglottis is at once exposed, and is drawn through the wound. The growth having been dealt with, and the bleeding checked, the wound is closed. The vessels wounded are few and insignificant, and the incision heals quickly.

Thyrotomy.—By thyrotomy is understood the division of the thyroid cartilage in the median line, so as to gain access to the interior of the larynx (II, Fig. 283). The operation is carried out for the purpose of removing certain laryngeal growths (Fig. 290), and certain large or impacted foreign bodies (Fig. 289), especially such as have found their way into the ventricles.

The operation involves a great danger of permanently interfering with vocalisation, and in the treatment of morbid growths it is only employed when the intralaryngeal method of removal cannot be effectually carried out.

Thyrotomy offers the most direct means of dealing with laryngeal growths, but in the case of papillomata (Fig. 290) rapid recurrence is the rule.

The Operation.—The head is extended over a hard cushion or sand-bag, and is firmly held with the chin in a line with the sternal notch. The shoulders are raised. Chloroform is the

anæsthetic administered. A preliminary laryngotomy or tracheotomy is carried out. The position of the opening for the tube will depend upon the nature of the case, the length of time the tube will probably have to be worn, and other circumstances. If the operation threatens to be extensive, as in dealing with large growths, a tracheotomy will be found to be the more convenient ; but in such an operation as is carried out for the removal of a foreign body, a laryngotomy may be selected.

If much hæmorrhage is anticipated, as will be the case in dealing with extensive papillomata, the trachea must be plugged. This may be effected by a tampon, such as Trendelenburg's tracheotomy tampon, or by gently plugging the trachea on either side of the tube with a piece of fine sponge properly shaped and attached to a long silk thread.

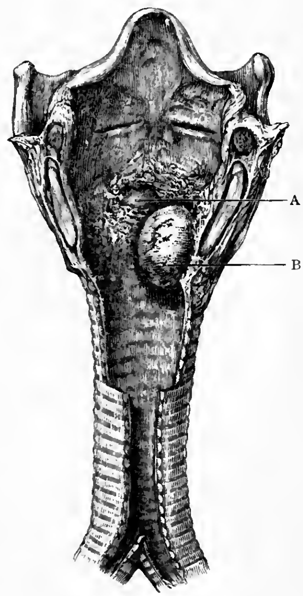

FIG. 289. — PEBBLE IMPACTED JUST BELOW VOCAL CORDS.

A, Ulcerated surface ; B, Pebble. (*St. Thomas's Hosp. Mus.*)

The incision is prolonged upwards in the median line, and the skin and subcutaneous tissues are divided down to the cartilage. The incision will extend over the cricoid and thyroid cartilages, the crico-thyroid space, and some part of the thyro-hyoid space.

The thyroid cartilage is divided accurately and carefully in the median line; the thyro-hyoid and crico-thyroid membranes being also cut if needed.

The division of the cartilage should be effected from above downwards, and from without inwards. In young subjects, and in females who have not passed middle life, the section may be accomplished by a small but stout knife. In aged subjects, in whom the cartilage will be calcified, a fine saw may be needed to effect a division. Bone forceps should never be employed.

By means of two small sharp hooks the two alæ are now drawn aside, and the interior of the larynx is exposed. In old

subjects it may be necessary to make transverse incisions in the crico-thyroid and thyro-hyoid membranes, close to their respective cartilages, before the fullest view desired can be obtained.

The foreign body may now be extracted, or the growth removed.

In dealing with papillomatous masses, the bulk of the growth may be crushed off with broad forceps, and the remainder removed with scissors, aided by Volkmann's spoon. The surface left by the removal of the tumour may then be touched with a saturated solution of chromic acid, or with a solution of formalin (1 in 100).

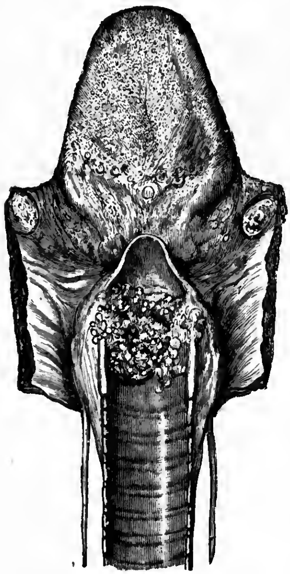

FIG. 290.—LARYNGEAL PAPILLOMA.

Finally, the two portions of the thyroid cartilage are united by two or three fine tendon or silver-wire sutures, and the wound in the skin is closed.

The results of thyrotomy in malignant disease are alluded to in the section (page 206) on the Results of Excision of the Larynx.

Thyrotomy for the removal of papillomata of the larynx has not been attended with much success, owing to the well-known tendency of these growths to recur. It is, moreover, open to the grave risk of damage to the vocal cords, and of stenosis. Intralaryngeal removal, performed under direct visual exposure through a straight tube passed through the mouth, is preferable, even though it may have to be repeated several times. Some surgeons wholly condemn thyrotomy in this condition. Tracheotomy alone has been advocated by Dr. G. Hunter Mackenzie, Dr. Railton, of Manchester, Mr. George Wright, and others. It will be necessary for the child to wear the tracheotomy tube for a long period, and hence much difficulty may be met with in its subsequent removal. For these reasons we strongly advise intralaryngeal removal over both tracheotomy and thyrotomy.

CHAPTER VI

EXCISION OF THE LARYNX

THE term laryngectomy has been applied to this operation. It involves the removal of either the whole of the larynx (complete excision), or of a considerable portion of it—usually one-half (partial excision).

The first complete excision of the larynx was performed by Dr. Patrick H. Watson in 1866, for stenosis of the larynx due to syphilis. The patient, a man aged thirty-six, died in three weeks (*Trans. Internat Med. Congress,* vol. iii., page 255, 1881).

The first complete excision for carcinoma, and the second operation in point of time, was carried out by Billroth in 1873 (*Archiv. f. klin. Chirurg.,* bd. xvii., page 343). Death took place from recurrence in seven months.

The first unilateral or partial excision was performed by Billroth in 1878, for carcinoma of the left side of the larynx.

Excisions of the larynx have since these dates been very frequently carried out.

Amongst the valuable papers on the subject the following deserve special attention:—Sir F. Semon, *Brit. Med. Journ.,* Oct. 31, 1903, and *New York Med. Rec.,* Nov. 5, 1904; Prof. Glück, *Brit. Med. Journ.,* Oct. 31, 1903; Dr. Maure, of Bordeaux, *ibid.*; Mr. H. T. Butlin, *Clin. Soc. Trans.,* vol. xxii., and "The Operative Surgery of Malignant Disease"; Dr. Solis-Cohen, of Philadelphia, "Internat. Encycl. of Surg.," vol. v., p. 776; Dr. C. Jackson, *Trans. Amer. Lar. Soc.,* 1904, p. 165; Dr. J. N. Mackenzie, of Baltimore, *ibid.,* April, 1900, and *New York Med. Rec.,* Nov. 4, 1905.

The subject of operations for laryngeal malignant disease is an exceedingly wide one, and includes three distinct operations—

1. Thyrotomy (usually combined with tracheotomy) and free

excision of the growth, and as much of the thyroid cartilage as is involved, but not a formal excision of one-half of the larynx;

2. Hemilaryngectomy with tracheotomy; and

3. Complete excision of the larynx, including the cricoid and thyroid cartilages.

Whenever the growth is sufficiently limited to allow (1) thyrotomy to be performed with fair prospect of success, this should be the method of choice. The mortality accompanying it is much less than that following the operations numbered 2 and 3.

Moreover, after complete excision of the larynx the patient's condition is usually most deplorable. An admirable account of the whole subject will be found in Jacobson and Rowland's "Operations of Surgery," pages 654 to 676.

COMPLETE EXCISION

Preliminary Tracheotomy.—This should be carried out at least one or two weeks before the excision is attempted.

The advantages of the step are these: The patient will get accustomed to breathing through an artificial opening. He will breathe more freely. He can be more conveniently anæsthetised. The trachea will become adherent to the integument, and will need no artificial support to prevent its descent when the larynx is severed from it. A little of the time of the operation will be saved.

A tracheotomy carried out some time before the excision is especially called for when the patient has much dyspnœa or dysphagia, and has suffered much loss of strength.

On the other hand, some surgeons (e.g. Gussenbauer) are opposed to preliminary tracheotomy, on the ground that it is not necessary and that it increases the risk of septic infection and broncho-pneumonia. We believe that most authorities still advocate it. It should be noted that preliminary tracheotomy need not involve an additional anæsthetic, as local anæsthesia will readily suffice.

Plugging the Trachea.—After the patient is anæsthetised, and before the actual excision is commenced, some means must be taken to prevent the entrance of blood into the air-passages. This is most surely effected by some form of tampon.

The well-known tampon of Trendelenburg is the one usually

employed. Semon's modification of this tampon has some advantages over the original instrument (Fig. 291).

The air sac must fill the trachea well. Mackenzie states that if the sac or air belt be too fully or too suddenly distended, an asthmatic paroxysm may be produced. In a case published by Sir Henry Morris (*Clin. Soc. Trans.*, vol. xx.) the tampon had to be given up on this account.

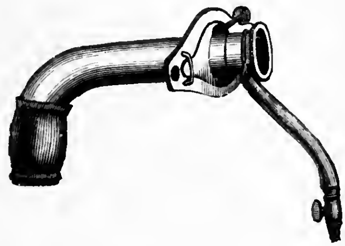

FIG. 291.—SEMON'S MODIFICATION OF TRENDELENBURG'S TAMPON-CANNULA.

Hahn's tampon-cannula is preferred by many (Fig. 292). It is thus described by Mr. Butlin:—"It consists of an inner and an outer tube. The inner is much longer than the outer, so as to project for one inch or one inch and a half in front of the shield. Blood is thus very unlikely to find its way into the mouth of the tube. And in order to prevent this projecting piece of metal from inconveniencing the operator, it is made to bend down parallel with the trachea for about an inch before it stands out at right angles to the neck. The lower end of the outer tube is provided with a raised rim about 2 mm. in height, and from this rim up to the shield it is covered with a layer of compressed sponge. Shortly—i.e. in ten minutes or a quarter of an hour—after the tube has been introduced, the sponge swells up from the absorption of moisture, and an absolute obstruction to the entrance of liquids into the trachea is provided." The tracheotomy tube may be fitted with a sheath of rubber, instead of sponge, by drawing a drainage tube over it.

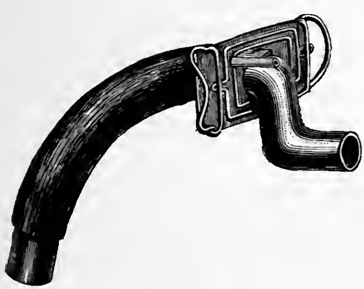

FIG. 292.—HAHN'S TAMPON-CANNULA.

Many surgeons discard all special apparatus, and use a simple cannula above which a piece of sponge is so inserted that it acts as a plug. This plug is inserted when the trachea is divided transversely, the lower division being always made

first, and hence this is the earliest stage at which blood can enter the larynx.

The Operation.—The patient lies upon the back, close to the right border of the table. The shoulders are raised, and the head is well extended over a hard cushion or sand-bag. The surgeon stands on the patient's right. The chief assistant takes his place at the head of the table and close to the surgeon's left. An incision is made in the median line from the centre of the thyro-hyoid membrane to the second or third ring of the trachea. At the upper end of this incision a transverse cut is made which is carried outwards on either side sufficiently far to reach the sterno-mastoid muscles.

The flaps thus marked out are turned back. Some division of the fibres of the sterno-mastoid muscles may be necessary. The vertical incision should go down to the thyroid and cricoid cartilages and the trachea.

The superior thyroid arteries may, if thought fit, be dealt with at this stage. They should be secured by two ligatures, and then divided between them. The vessels would be sought for at the posterior margin of the thyro-hyoid muscle, close to the upper border of the thyroid cartilage.

Branches from the inferior thyroid arteries to the larynx will also require ligature during the operation.

The fascia having been well divided in the middle line, a broad periosteal elevator or a rugine is introduced, and by means of it the soft parts can be separated from the laryngeal cartilages without employing the knife.

The crico-thyroid, sterno-thyroid, and thyro-hyoid muscles are detached on one side, and are, together with the other soft parts, held with a retractor while the larynx, by means of a sharp double hook, is drawn over to the other side. The attachment of the inferior constrictor muscle to the thyroid cartilage can now be severed, partly by detachment with the elevator or rugine, and partly by cutting it with curved blunt-pointed scissors, which are kept very close to the cartilage. The larynx is now pulled forwards as well as to the opposite side, and the tissues are divided about the gap which intervenes between the cut and now separated ends of the superior thyroid artery.

The superior laryngeal nerve is also now divided. The thyroid gland is pushed aside with the soft parts.

If the larynx be now well drawn over to the other side, the other half of the organ can be stripped of its coverings in precisely the same manner.

The next step is to divide the thyro-hyoid ligaments and membrane, and to cut the extralaryngeal connections of the epiglottis. This structure may be conveniently drawn forwards while its attachments are being freed.

The entire larynx is now pulled forwards by means of sharp hooks introduced into its upper part, and the organ is separated from its remaining connections with the pharynx and œsophagus —at first laterally, and then from above downwards.

If proper care be taken, the œsophagus should be nowhere "button-holed." Special care is required to separate the cricoid cartilage from the commencement of the gullet.

The trachea is now secured (unless already adherent) by means of two ligatures, which are held by an assistant, and the excision is completed by dividing the membrane between the cricoid cartilage and the trachea from behind forwards.

One or more rings of the trachea may be removed at the same time if it be considered necessary.

The upper end of the divided trachea, which has been prevented from slipping down by the two ligatures, is now secured to the integument by several points of interrupted suture.

Three or four deep sutures of silver wire are passed beneath the uppermost ring, and are made to attach the windpipe securely to the skin; a further series of fine superficial sutures unite the mucous membrane of the trachea to the cut margin of the skin.

The bleeding throughout the operation will be free, and each small vessel should be ligatured as soon as it is divided. The limited space does not favour the use of many pressure forceps.

Modifications of the Operation.—*Excision of the Larynx from below upwards.*—This order of proceeding is advised by some. The vertical skin incision having been made, the soft parts are detached from the front and sides of the larynx, and the trachea is exposed. It is divided below the cricoid cartilage, is raised

out of the wound, and is secured to the skin. A cannula is introduced into its lumen, and the tube around is closed by a plug of sponge, to which—as a precaution—a long silk thread is attached.

The larynx is now detached from below upwards.

This method is claimed to be the easier of the two, but it is not recommended by those who are most competent to advise upon the point.

Splitting the Larynx.—In cases where any doubt exists as to the extent of the disease, it is advised that the thyroid cartilage be split open in the median line, and the interior examined, before it is decided that the whole of the larynx must be sacrificed.

The Epiglottis.—Few arguments have been advanced in favour of retaining the epiglottis in cases in which it has been found to be sound. The arguments in favour of removing it are these: It is of no functional value, it may become the seat of a rapidly-recurring growth, and it interferes with the introduction of an artificial larynx.

The Cricoid Cartilage.—This structure is in most cases removed. When sound, it is advised by some that it be retained, on the ground that it affords an important additional support for an artificial larynx. Hahn, on the other hand, declares that, if left, it interferes seriously with the act of swallowing, and that it should in every case be removed with the rest of the larynx.

General Observations.—In clearing the larynx, it is most important that the surgeon should keep throughout as close as possible to the cartilages, and that if a knife be used, he should cut upon the cartilages.

It may sometimes be necessary to divide the isthmus of the thyroid between two ligatures when it is found that there is a difficulty in displacing that body from the larynx.

If any enlarged cervical glands be discovered, they should be removed.

If, after the skin has been reflected, it is found that the carcinoma has extended beyond the larynx, and has invaded the surrounding muscles and connective tissue, the operation should be abandoned.

After-treatment.—The wound is well cleansed with aseptic pads, and is then filled with a light packing of sterilised or

iodoform gauze. No sutures are introduced, except in the transverse part of the skin-wound, the edges of which may be brought together by a few points of silkworm gut. A soft indiarubber tube is introduced into the stomach through the wound, and is secured in position by a suture. Through this tube the patient is fed. This mode of feeding must be supplemented by nutrient enemata. The tampon-cannula used in the operation is left undisturbed.

The patient must be placed in a warm and well-ventilated room, and, if it be considered desirable, a steam spray may be used to render the inspired air moister.

The gauze dressings should be changed twice or three times in the twenty-four hours, and every care be taken to prevent decomposition from occurring in the wound, and to allow all discharges and secretions to escape.

The tampon-cannula may be removed at the end of twenty-four or forty-eight hours, and replaced by a tracheotomy tube of the largest size. Some surgeons retain the tampon for eight or ten days, as a precaution against the somewhat unlikely accident of secondary hæmorrhage. The tracheotomy tube must be kept scrupulously clean.

As soon as the wound is becoming firm, and the healing has advanced satisfactorily, the œsophageal tube may be removed, and the patient either be encouraged to swallow, or the tube be introduced from time to time as circumstances suggest. The feeding-tube has been left off as early as the fifth day, but it may, on the other hand, have to be worn for some weeks. Mr. Jacobson recommends that the feeding-tube should from the first be introduced through the nose or mouth, and not from the wound.

It must be borne in mind that it will be easier to swallow solid than liquid food in these cases, and that not a few deaths have been due to pneumonia, consequent upon the decomposition of food which has found its way into the air-passages.

Other elements in the treatment of the case will depend upon ordinary surgical principles.

The Artificial Larynx.—This instrument should not be introduced until the parts are satisfactorily healed, and from three to five weeks will usually elapse after the operation before

any attempts to make use of the artificial larynx will be considered advisable.

The apparatus that appears to be the most satisfactory is Irvine's modification of Gussenbauer's instrument.

It consists of two tubes, a pharyngeal tube (Fig. 293, A) and a tracheal tube (Fig. 293, B). The pharyngeal tube is introduced first, and the tracheal tube is then passed through it. Fenestræ are so cut in these two tubes as to allow of the free passage of air throughout them. Lodged in a groove in the pharyngeal tube is a plate carrying a reed (Fig. 293, C). This plate can be pushed in and drawn out after the manner of a table-drawer. It can therefore be readily freed from mucus, and cleaned. The expiratory current produces vibration of the reed, and the tone evolved serves as a basis for articulate speech. The sound is, of course, absolutely monotonous.

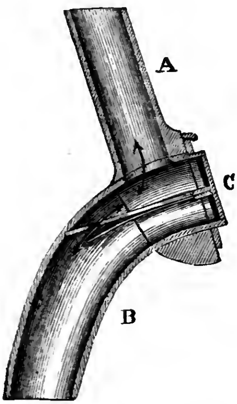

FIG. 293.—IRVINE'S MODIFICATION OF GUSSENBAUER'S ARTIFICIAL LARYNX.

A, Upper tube; B, Lower tube; C, Reed.

Dr. Solis-Cohen comments as follows upon this instrument:—"Great difference is presented in the toleration of these appliances. In some instances they give little trouble, and are used with great comfort. Some subjects bear the naked apparatus well, but cannot tolerate the phonal reed, which may impede respiration, may become obstructed with desiccated mucus, and may yield a tone to every breath of expiration. Some abandon them altogether, and stick to the simple tracheal cannula. In some instances saliva, mucus, and aliment will get into the tubes and descend into the trachea. Some patients prevent the escape of food by plugging the upper orifice with cotton when they eat."

PARTIAL EXCISION

This operation is carried out upon the same lines as the complete excision. One-half only of the larynx or of the thyroid cartilage is removed. The details of the operation are practically the same.

A preliminary low tracheotomy may be carried out some little time before the excision is attempted.

The incision is the same, save that the transverse portion need occupy only the diseased side. A tampon-cannula is introduced.

The larynx is laid bare in the middle line, and the thyroid cartilage is divided so that the interior of the larynx may be inspected. Preliminary ligature of the thyroid arteries is unnecessary.

The thyroid cartilage is now removed. It is cautiously bared of the soft parts which cover its outer surface, by means of an elevator or a rugine. The surgeon must keep close to the cartilage. The attachments of the pharynx are separated by like means. The thyro-hyoid and crico-thyroid membranes are divided upon the affected side as closely as possible to the margin of the thyroid cartilage. The superior cornu of this cartilage is divided at its base by pliers. The epiglottis is left, and the aryteno-epiglottic fold of the affected side is divided close to the cartilage of Wrisberg. In some cases the epiglottis has been split, and one-half removed.

Every care must be taken to avoid opening the pharyngeal cavity. In clearing the cartilage, the elevator and the handle of the scalpel may be now and then assisted by a few snips from blunt-pointed scissors curved on the flat. Bleeding vessels must be taken up and tied as divided.

Mr. Butlin states that in partial excision for intrinsic disease "there is usually not the least necessity to remove the cricoid cartilage." It has, however, in most of the cases been split in the middle line, and one half of the ring has been removed with the half of the thyroid cartilage.

Mr. Butlin is in favour of leaving the thyroid cartilage also, whenever this is possible. He would split the cartilage in the middle line, open the larynx, and then scoop out, as it were, the contents of one-half of the thyroid cartilage. The removal should be free, and when completed the ala should be restored in place. Mr. Butlin points out that cancer of the larynx far more often causes the death of the cartilage piece by piece than infiltrates it; and even if the surface of the thyroid has been encroached upon, he would be disposed to scrape away the affected part rather than sacrifice the whole ala.

Sir F. Semon (*Monats. f. Ohrenh.*, November, 1899) supports this method of operation by a series of fifteen cases treated by thyrotomy. One patient died of the operation, and ten were alive and well at intervals of from one to eight years afterwards.

The after-treatment is the same as in cases of complete excision. The treatment of the wound is the same. The patient will probably be able to take semi-solid food by the mouth in three or four days after the operation, and the cannula may often be dispensed with in the same time.

Results of Excision of the Larynx.—The usual causes of death are shock and hæmorrhage, and, above all, pneumonia. The risk of death from pneumonia must be present for at least fourteen days after the operation. The failure of antiseptic precautions, the passage of food and discharges into the bronchi, and the development of bronchitis from the altered mode of breathing, are the usual factors in the production of this complication. In complete excision the mortality directly due to the operation itself is over thirty per cent. In partial excision it is less.

The relief afforded in complete excision has been, in the majority of cases, of but short duration, early recurrence being the rule. The state of some of the patients after the operation has been very miserable. If it be true that a palliative tracheotomy in cancer of the larynx may allow life to be prolonged some two and a half years, there must be strong evidence adduced to justify the complete removal of the organ.

The immediate success which has attended partial excision of the larynx in suitable cases has been more gratifying. The mortality has been lower, and the patient has been able to swallow with ease, and to speak with sufficient clearness to enable him to make himself quite understood. With regard to complete excision, Mr. Butlin wrote in 1887:—"Complete excision of the larynx has hitherto been in every respect unsuccessful. . . . And were it not that better results may be hoped for in future—by better management of the patients, and by much greater care in the selection of cases—the operation must be condemned as unsurgical."

A later review of this question is given by Mr. Butlin in the *British Medical Journal* for August 23rd, 1890. A list of more recent references has already been given on page 197.

The following table is taken from Mr. Butlin's paper :—

	OPERATIONS FOR MALIGNANT DISEASE.	DEATHS DUE TO THE OPERATION.
Thyrotomy	28 cases . .	3 deaths
Partial excision of larynx . .	23 ,, . .	7 ,,
Complete excision of larynx . .	51 ,, . .	16 ,,
	102 ,,	26 ,,

Out of the 28 cases of thyrotomy . . .	3	are pronounced cured
,, 23 ,, partial excision . .	4	,, ,, ,,
,, 51 ,, complete excision .	8	,, ,, ,,
102 cases.	15	cases of cure.

[By "cure" it is meant that the patients were alive and free from disease at periods of from three to twenty years after the operation.]

Sendziak (*Monats. f. Ohrenh.*, Berlin, September, 1899) has tabulated the results in 640 cases of operation for cancer of the larynx. This paper shows that the mortality was much lower after thyrotomy (6·6 per cent.) than after complete excision (14·2 per cent.). The cures after complete excision were estimated at 1·5 per cent., after thyrotomy at 11 per cent. The prognosis evidently depends upon getting the case early enough, when the cancer is intrinsic and can be treated by thyrotomy with success.

Other recent collections of cases lead us to place the direct mortality of both partial and complete excision of the larynx considerably higher than Sendziak states. It must be remembered that only successful cases tend to get into the literature. After complete excision the mortality is probably 30 to 40 per cent. ; after partial excision, 25 per cent.

CHAPTER VII

OPERATIONS ON THE THYROID BODY

REMOVAL OF GOITRE, ETC.

Anatomical Points.—The normal relations of the thyroid gland or body must be clearly appreciated before any operation is attempted upon this dangerously-placed structure.

Most important is it to note the relations of the gland to the trachea and gullet, to the recurrent laryngeal nerve, and to the sheath of the great vessels of the neck.

The thyroid gland has a very large blood supply. The superior thyroid arteries—from the carotids—descend to reach the apex or upper part of each lobe. They supply the front and inner parts of the body. The inferior thyroid arteries are larger than the superior, enter the lower extremity of each lobe, and supply the posterior, inferior, and outer parts of the body. Each vessel runs for some little distance on the posterior surface of the thyroid before piercing it. The deep position of the inferior thyroid artery should be remembered—it passes behind the carotid sheath and the sympathetic nerve as it approaches the thyroid gland, and divides into two or more branches. The artery is in very close relation to the recurrent laryngeal nerve, lying as a rule just in front of the nerve, but occasionally behind it. It may even twist round the nerve. For these reasons it is best, in excising one lobe of the thyroid gland, to clasp and ligature the main branches of the artery close to the gland, and not to secure the main trunk further away from it. (*See*, however, Baumgartner's advice on page 215.) The thyroidea ima may supplement deficiencies in the other arteries, and when present will enter the lower part of the gland near the median line.

The superior thyroid veins follow the arteries, and end in the internal jugular. The middle thyroid veins pass out transversely, and enter the internal jugular a little below the level

of the cricoid cartilage. The inferior thyroid veins descend as an irregular plexus on the trachea, and end in the innominate veins. In extirpation of a goitre care should be taken to clamp or ligature each vein securely before dividing it.

The quantity of blood contained in the softer varieties of goitre is enormous, and the size and number of the veins which leave it are remarkable. They are thin-walled and not well supported, hence roughness in making traction on the thyroid gland during operation may lead to serious and even fatal hæmorrhage.

Partial or complete excision of the thyroid gland is usually carried out in certain selected cases of non-malignant bronchocele, especially in such as are causing severe disturbance from pressure. In the treatment of malignant disease of the thyroid the experience of surgeons up to the present time has been so unsatisfactory as to render it a question whether the operation is justifiable. It is, however, satisfactory that in a certain number of cases of adeno-carcinoma of the thyroid excision has been followed by a long period of freedom from recurrence, and in a few by cure. Each case must be decided for itself. The unilateral cases of malignant disease are the most favourable for operation; a soft, bilateral, rapidly-growing and infiltrating growth should certainly not be touched.

The question of operation in cases of exophthalmic goitre (Graves' or Basedow's disease) is referred to on page 219.

The very great majority of operations on the thyroid are for bronchocele, or adenomatous enlargement of the gland.

It will be evident that in cases of bronchocele the relations of parts may be much modified, essential landmarks may be lost, and vessels and other structures displaced.

The bronchocele may extend to great depths, may surround the trachea, and may have so insinuated itself among the various structures of the neck as to render any attempt at excision either desperate or entirely unjustifiable. One important form of goitre is the substernal one, in which an abnormally low portion of the gland enlarges and may produce rapid obstruction of the trachea behind the sternum. Operation should always be resorted to as early as possible in these cases.

Dangers of the Operation.—In some instances, when the

bronchocele is small and well encapsuled, its enucleation, or the excision of one-half of the gland, may be carried out without much difficulty. But these simple cases probably do not form more than half the number that require operation.

In many instances these excision operations are dangerous, tedious, and difficult, and demand the exercise of the highest qualities of a good surgeon. The larger the mass, the less defined its capsule, the broader its base, and the more vascular its structure, the less easy is the operation. The following are the principal dangers :—

1. *Hæmorrhage.*—In the course of the excision there is no great difficulty in dealing with the arteries. It is the veins which are the source of the trouble. They are found to be numerous, to be very large, to be arranged according to no familiar anatomical lines, and to be usually thin-walled. The dyspnœa from which the patient suffers causes them to be abnormally distended, and to bleed furiously if they be accidentally divided.

In the softer and more vascular forms of bronchocele the splitting of the comparatively thin capsule exposes a soft pulpy tissue, from which blood pours as if it were being wrung out of a sponge. No form of bleeding is less easy to deal with than this.

In indistinctly encapsuled and wide-spreading goitres the carotid artery and the jugular vein are in danger, and the artery may be wounded or the vein torn.

2. *Injury to the Recurrent Laryngeal Nerve.*—This nerve is in intimate relation with the inferior thyroid artery, and in securing that vessel—or, rather, the series of vessels which represent it—it is by no means difficult to damage this important nerve. The accident has happened many times. The nerve has been in some instances cut, in others it has been included in a ligature, and in a third series of instances it has been torn or severely stretched.

3. *Cellulitis.*—So extensive a tract of the connective tissue of the neck is opened up that if the wound become septic, there is little to prevent a diffused form of suppurative cellulitis, which will almost inevitably lead to death.

Hence, a preliminary tracheotomy adds decidedly to the

risk of the major operation, owing to the chance of septic infection of the wound. When severe dyspnœa is produced by the pressure of a goitre on the trachea, it should be treated, if possible, by excision of the tumour and not by tracheotomy.

The special risks of general anæsthesia in all goitre operations are discussed on page 212.

Complete Excision.—This term is used in an elastic manner—for complete excision in the sense of removing the whole of both lobes and the isthmus should never be performed, because of the great risk of the gradual development of a "cachexia strumipriva." This condition resembles myxœdema, and is inevitably fatal in its ending. Hence, some portion of the thyroid gland should always be left behind; it will hypertrophy, and prevent this unfortunate result of the excision.

In many cases the enlargement is chiefly of one lateral lobe, and the surgeon will then, as a rule, operate on this side—removing the whole of one lobe and part of the isthmus. In others it is necessary to remove more than this.

In the description that follows repeated use will be made of Professor Kocher's unrivalled experience—recorded in his "Operative Surgery" (3rd edition, pages 133 to 151), and in many papers.

It must be noted that individual cases differ a good deal, making slight modifications in the procedure necessary.

Special Instruments Required and Preliminary Arrangements.—Four special instruments are figured by Kocher: 1. A "goitre-spoon" of metal, used for lifting up intrathoracic goitre. This may easily be improvised. 2. A goitre-forceps, with ringed ends and recurved hooks. The fenestrated volsellum forceps will answer the same purpose. 3. A goitre-dissector, which is simply a broad, short elevator. 4. A crushing clamp forceps, for seizing the isthmus. If the surgeon uses crushing, a pair of slightly-curved intestinal forceps will answer.

Abundant Wells' forceps (the lighter the better). Two or three excision needles of different curves. Curved scissors of at least two sizes. Fine Japanese silk is the best material for all ligatures.

The patient lies with the shoulders well raised and the head

extended over a large sand-bag or hard cushion. The upward slope of head and shoulders diminishes venous congestion, and is convenient to the operator. The chin should be kept in a line with the sternal notch, and the head be well fixed. The anæsthetist stands at the head of the table, and the chief assistant to the surgeon's right. Every preparation must be made for extensive hæmorrhage. The anæsthetic should be chloroform, or at least the A.C.E. mixture, should chloroform be distinctly contra-indicated. Ether increases to its utmost the engorgement of the veins of the head and neck.

FIG. 294. — SYMMETRICAL BRONCHOCELE, SHOWING KOCHER'S ANGULAR INCISION (DOTTED LINE).

The "collar incision" alluded to in the text would be placed low down over the most projecting part of the tumour, running from side to side parallel with or in the position of the continuous line.

If a general anæsthetic be used, the patient should be kept only just under its influence. Owing to the special danger in goitre operations of sudden dyspnœa, Professor Kocher strongly recommends eucain or cocain and morphia injections instead of a general anæsthetic. A preliminary injection of morphia ($\frac{1}{6}$ to $\frac{1}{4}$ of a grain) and the local injections of eucain (1 to 2 per cent. solution) will enable the surgeon to carry out a formidable operation, the most painful step being the final insertion of the sutures.

The Incision.—This may be made in the median line from the sternal notch to the upper limit of the bronchocele. From this point two lateral incisions are made upwards and outwards, one on each side. They are directed towards a point a little below the angle of the jaw, and when the cutaneous cut is com-

plete it will have the outline of the letter **Y**. If the tumour be much more extensively developed on one side than on the other, the upper or oblique incision may be limited to the affected side. In any case the incision must not be spared. A primary requirement is that the tumour be very freely exposed. The lateral or oblique cuts will usually pass over the anterior borders of the sterno-mastoid muscles.

The incision described, if made on one side only (*see* the dotted line in Fig. 294) corresponds to Kocher's "angular incision." But for most cases Kocher recommends (and is supported by Messrs. A. E. Barker and Berry) the "collar incision." This is a curved one, following a natural crease in the skin, and extending from over one sterno-mastoid to the other. The advantage claimed for it is the inconspicuous scar.

FIG. 295.—ENLARGED THYROID WITH PRESSURE SYMPTOMS.

The dotted line marks the skin incision for dealing with the left lobe.

We have frequently employed a more sharply curved incision over the outer and lower edge of the enlarged lobe; i.e. curving down the anterior border of the sterno-mastoid and then across the lower border of the isthmus of the gland. This, it will be seen, is Kocher's angular incision reversed; we have been well pleased with it. Whatever incision be used it should be free; nothing is worse than to operate here through a too small wound. (Fig. 295.)

The platysma and fascia are divided. Any veins which are met with are secured between two ligatures of catgut, and divided. The sterno-hyoid and sterno-thyroid muscles will be found to be stretched over the goitre. These structures will probably be thinned and altered in appearance.

The surgeon must make his way down to the gland, and must convince himself that he has opened up the plane of

connective tissue beneath these muscles, and is not wandering aimlessly over the outer surface.

The sterno-hyoid, sterno-thyroid, and omo-hyoid muscles should be respected as far as possible, and drawn to the outer side of the tumour. It may be necessary partially to divide one or other of these muscles.

The muscles named will very often be closely adherent to the tumour, and in clearing them away the scalpel must be used very sparingly.

No instrument is more serviceable in this stage of the operation than a broad periosteal elevator. Its point is so blunt that it can do little damage, and its configuration is admirably suited to peel the tissues away from the capsule. This must be done with great care. The elevator is made to work its way beneath the muscles and the fascia, and when the precise relations are clear the tissues are divided over the elevator as over a director. In effecting this exposure of the goitre a pair of blunt-pointed scissors curved on the flat is more useful than a scalpel, and the handle of the scalpel is of more service than the blade. The elevator must not be vigorously thrust here and there, but must be made to find an easy path. No tissue should be cut until it has been well examined, and any especially resisting structure must be exposed before it is torn across or cut.

A plexus of large, thin-walled veins will usually be found covering the tumour. They must be separately treated, and must be individually divided between two ligatures. These vessels are easily torn across, and are very apt also to be adherent.

If the head be in the position of extension, the structures on the front of the neck, and especially those over the face of the tumour, are apt to be stretched, and a vein so stretched may be quite unrecognisable. It is well, therefore, to have the head lifted now and then, so that the veins to be dealt with may be brought well into view.

Step by step the surgeon clears the whole of the front surface of the swelling, dealing with every bleeding point as it is met with, and not trusting either to the pressure of fingers or of sponges, or to artery forceps.

When the anterior surface is cleared, the next step is to approach the lateral margins of the growth, and to secure the thyroid vessels. It must be remembered that the thyroid body touches the carotid sheath. The position of that vessel should be made out as early as possible, and the utmost care taken to avoid it. If the bronchocele is in close contact with the main vessels, some special care may be required in separating the huge internal jugular vein from the capsule. The superior thyroid artery is then sought for at the upper extremity of the tumour. It may not be made out without some difficulty. If the vessels cannot be individually isolated, a double ligature may be passed by means of an aneurysm needle, and the vascular pedicle ligatured in two places and divided between. The vessels embraced by these ligatures may be separately sutured at a later period if thought necessary. The inferior thyroid artery is less easy to deal with. It is more deeply placed, has more numerous veins in relation with it, and is closely connected with the recurrent laryngeal nerve. No pains should be spared to expose it well. Baumgartner recommends that the ligatures be applied at some distance from the lower border of the tumour, and that the branches of the artery be cut through just as they enter the bronchocele. In this way there is less danger of including the recurrent nerves.

The whole of the lateral border of the tumour is now separated. The same precautions are observed. The blunt elevator is the chief instrument. The scissors are used as required, and the vessels encountered are all ligatured and divided in the manner described.

The mass is turned over towards the opposite side, and the posterior surface of the tumour cleared as far as the posterior median line.

The other lateral lobe is dealt with in the same manner. It is, however, absolutely essential that a fair amount of gland tissue should be left behind with its own arterial supply intact. This involves section of some part of the gland with the aid of the clamp, the exact level of section depending to some extent upon the extent of the disease. But speaking generally, at least one-third or one-half of a lateral lobe should be left.

The wound is now examined, and any remaining bleeding

vessels are secured. No irritating antiseptic solutions should be used to the wound. The less it is rubbed with a sponge the better. The margins of the skin incisions are united with silk-worm-gut sutures, which are not too closely applied. A drainage-tube is rarely necessary, though a fine spiral one will do no harm.

The best dressing consists of a large pad of sterilised gauze and wool, the former being dry when applied. It is bandaged in position, with as much pressure as it is considered safe to apply, by means of a light muslin bandage.

When the patient is placed in bed, the shoulders and head must be kept well raised, and the head may be fixed in the hollow of a loosely-filled sand-bag.

Partial Excision.—Excision of one-half of the thyroid, with division of the isthmus, is conducted in precisely the same manner as the above operation.

The incision is usually oblique, made along the anterior border of the sterno-mastoid muscle. The front of the bronchocele is cleared, and the superior thyroid artery secured.

After this vessel has been dealt with the isthmus is severed. The fascia around it is divided, and the isthmus is then separated from the trachea by an elevator or director, and is well isolated. It may then be transfixed by a needle in a handle—such as is used in ovariotomy—and secured by a double set of ligatures, which are placed upon each side of the spot at which it is intended to divide it. It is treated somewhat like the ovarian pedicle. In cases of very large isthmus, more ligatures may be called for. In some instances the isthmus may be more conveniently divided with a scalpel, and ligatures applied as required. Kocher advises that the isthmus should be crushed with the clamp forceps, so that when they are taken off only the connective tissue capsule and vessels are left; these are secured by a ligature.

The tumour is now almost completely isolated, and the last step consists in ligaturing the inferior thyroid artery.

It answers equally well to secure the inferior thyroid vessels, and to dislocate the gland forwards out of the wound before dividing the isthmus. This order of procedure is recommended by Kocher.

Enucleation.—When a goitre consists of a localised cyst

or adenoma, it may be enucleated by peeling off the surrounding gland by means of an elevator. Care must be taken that the incision goes down into the actual wall of the tumour, and the size of the latter may often be diminished by tapping before it is shelled out. A formal ligature of the main thyroid vessels is not required, but all vessels going into the tumour should be secured with pressure forceps before division.

Mr. Berry recommends in these cases a transverse incision placed low down in the neck, as the resulting scar will be less conspicuous than a vertical or oblique one. The transverse incision, however, does not give so much room as the others, and the exact place of the incision must depend upon that of the adenoma or cyst.

Tracheotomy in these Operations.—If there be much dyspnœa in these cases of excision of the thyroid, the mass should be relieved from its tense surroundings as soon as possible, and the pressure removed from the trachea. Some assistance in this direction may be afforded by altering the position of the head, and by having the mass, as far as possible, withdrawn from the windpipe.

More immediate relief may be obtained probably by dividing the isthmus.

Tracheotomy is most emphatically to be avoided. The operation, if performed, would be carried out under the greatest difficulties, and the gravity of the whole procedure much increased.

Tracheotomy in these cases nearly always leads to a fatal issue. It is impossible to prevent the huge wound from becoming septic, and the patient soon dies of septic pneumonia or suppurative cellulitis. An excision of the thyroid, accompanied by tracheotomy, is so desperate an operation that it must be regarded as quite unjustifiable as a deliberately planned procedure. In most of the cases the tracheotomy was called for unexpectedly after the excision had been commenced; but to complete an excision after a tracheotomy has been performed is a forlorn hope indeed.

After-Treatment.—This calls for no especial notice. If a

drainage-tube has been used, it should be removed in twenty-four or thirty-six hours.

The shoulders should be kept raised, and the head well fixed, by being buried in a sand-bag.

In applying the dressings the bandages must be passed under the axilla, across the front of the chest, across the scapular region, and over the head, in order to secure a firm and even covering for the wound.

The food should be fluid or soft for some days.

The treatment is, indeed, that merely of a deep and extensive wound in the neck. The healing of such a wound is, as a rule, most satisfactory, and suppuration, even of a slight degree, ought very rarely to occur. The scar, if fine silkworm-gut sutures have been carefully applied, and if the depressor muscles have been left intact, will probably be quite inconspicuous. Should there be delay in healing it may be well to keep the neck immobile by the use of a poroplastic case outside the dressing.

Results.—These operations, besides involving the ordinary surgical issues, involve also, in the cases of complete excision, the possibility of cachexia strumipriva. The matter has been carefully investigated by the committee of the Clinical Society on Myxœdema (*Clin. Soc. Trans.*, Supplement to vol. xxi., 1888, pages 162, 197).

The results are given as follows :—

" In a total of about 408 intentionally complete thyroidectomies, performed by fifty-six different surgeons, there were fifty-nine deaths in consequence of, or shortly after, the operation.

" In twenty cases the operation was performed for malignant disease of the thyroid gland.

" Deducting the cases of death from, or shortly after, the operation, the cases in which there was malignant disease of the thyroid gland, and the cases which were lost from observation almost immediately after the operation, there remain 298 cases in which total thyroidectomy was performed for simple goitre, and in which the patients are known to have fully recovered. Of these, in 277 instances the further fate of the patients could be followed up, with the result that in twenty-two cases either recurrence of goitre, or development of accessory thyroid glands, appears to have taken place; that in 186

cases the patients appear to have remained free from cachexia strumipriva, without recurrence or development of accessory thryoids having taken place; and that in sixty-nine, cachexia strumipriva of a more or less severe type developed."

The grave warning indicated by these figures has, of course, had its effect, and now that surgeons know how to avoid producing myxœdema and are careful to leave behind a certain amount of gland tissue, this particular risk may be said to have disappeared.

With regard to the ordinary cases of cystic or parenchymatous goitre, the experience of some Continental surgeons has been very large; for instance, Professor Kocher of Berne has performed over 2,000 such operations, with a mortality of 6 per cent. He is a strong advocate of aseptic, as distinguished from antiseptic, methods, and of local in preference to general anæsthesia.

Mr. James Berry (*Brit. Med. Journ.*, July 7th, 1900, and *Trans. of Royal Soc. of Med.*, 1907) has published valuable and very full records of his experience—about 200 operations. His mortality was as low as Professor Kocher's, and it is interesting to note that his operations were mostly performed under general anæsthesia.

Mr. A. E. Barker (*Practitioner*, September, 1907) advises local anæsthesia by injection of the following solution: Beta-eucain, 1 in 500; adrenalin, 1 in 200,000; of normal saline solution. As much as 200 c.c.—i.e. 6 or 7 ounces—of this solution may be injected. Adrenalin delays the onset of anæsthesia, and hence the operation should not be begun until thirty minutes have elapsed after the first injection.

Thyroidectomy for Exophthalmic Goitre (Graves' Disease).—The evidence with regard to the value of this operation is strangely conflicting. Thus by some it is considered to be the only radical treatment, and Kocher urges that it should be done in the early stages of the disease. Of fifty-nine cases operated on by himself, cure or marked improvement is asserted to have followed in 75 per cent. Yet it is admitted that in many the nervous symptoms were even worse after than before the thyroidectomy.

The direct mortality of the operation (124 cases, seven deaths)

is claimed by Kocher to be 5 per cent. The employment of ocal anæsthesia may diminish this somewhat. As to the special dangers of general anæsthesia in exophthalmic goitre all operators are agreed. If operation be decided on, one-half of the thyroid gland—that which is most enlarged—should be removed under local anæsthesia (eucain or cocain injections). Should the symptoms continue unrelieved at a subsequent operation, the greater part, but on no account the whole, of the other lobe should be excised.

Professor Kocher for some time advocated ligature of the superior and inferior thyroid arteries in preference to excision of part of the gland (*see* Kocher, "Operative Surgery," 1903, page 151); but the results were apparently too unsatisfactory or uncertain, and he reverted to excision, which he had described as "often too dangerous," an opinion which experience in this country would heartily endorse.

Mr. Berry, for example, is against operating on any cases of exophthalmic goitre.

For early or slightly marked cases the operation may be attended with as moderate a risk as given above, but then complete rest and appropriate medical treatment are usually so successful that an operation can hardly be justified. On the other hands in the progressive and advanced cases we are certain that the death-rate of operation is nearer 50 than 5 per cent. It is the cardiac condition that is responsible for this, and even though no general anæsthetic be given, such patients are dangerous subjects for surgical interference. For example, in one of our cases sudden death occurred a few hours before the time fixed for operation.

CHAPTER VIII

EXCISION OF THE EYE-BALL AND OF THE LACHRYMAL SAC

THE description of most ophthalmic operations, such as iridectomy, extraction of cataract, tenotomy and advancement of ocular muscles, etc., must be omitted in this work. Two operations on the eye and its appendages can alone be referred to here, excision of the globe and of the lachrymal sac.

EXCISION OF THE GLOBE

Instruments required.—Spring speculum with screw-catch; strabismus hook (Graefe's pattern); small scissors, curved on the flat, and blunt-pointed; fine-toothed forceps.

A general anæsthetic should always be given. The actual stretching and division of the optic nerve may be attended with some reflex shock, but this is usually slight.

The Operation.—The spring speculum (the handle of which should be well curved so as to lie out of the way) is inserted and fixed by its screw-catch, the lids being thus separated as widely as possible. The operator catches up conjunctiva and Tenon's capsule, close to the cornea and at the lower edge of the external rectus insertion. The piece caught up is severed with the scissors so as to make an opening for the strabismus hook. The point of this, directed backwards towards the apex of the orbit, is slipped into Tenon's space under the external rectus insertion, the handle of the hook depressed, and the external rectus, with sheath and conjunctiva, divided between the hook which puts them on the stretch and the cornea.

The upper, internal and inferior recti are dealt with in the same way, so that hook and scissors pass completely round the front of the eye-ball. At each insertion of the hook its end should be first directed backwards close to the eye-ball, so as to get under the recti.

The stop or catch on the speculum is now released, and the globe pressed forwards between the speculum blades. If the eye-ball is inflamed, or the site of a soft tumour, care should be taken to do this manœuvre very gently, or the globe may rupture.

As the eye comes forwards the optic nerve is put on the stretch, the globe being steadied with the fixation-forceps or fingers of the left hand, and the curved scissors are insinuated slightly open round the outer side of the globe, so as to divide the nerve close to the former. The insertion of the two oblique muscles and any remaining strands of tissue are divided, the scissors keeping close to the globe throughout the operation.

The speculum is removed, and a small pad of sponge or other aseptic dressing applied at once *over* the closed lids, being secured there by a few turns of a narrow light bandage (muslin by choice). The latter must be prevented from slipping by being passed alternately above and below the ears. Firm pressure alone suffices to prevent further oozing under the dressing, and no other form of hæmostasis is practicable.

After twenty-four or forty-eight hours the dressing is changed, and the pressure relaxed.

It will generally be a few weeks before an artificial eye is tolerated.

Comment and Modifications.—The secret of excising an eye-ball neatly depends on three points: 1. Be sure to open Tenon's capsule in starting, and keep the scissor points as near the cornea as possible. 2. Work close to the sclerotic with the scissors, but do not rupture or incise that layer. 3. Open the scissor blades sufficiently to get the optic nerve between them, and divide it at the first attempt, just behind the sclerotic. If, however, the excision is for glioma, it is well to take as much of the optic nerve as can be reached. If for sarcoma, or other tumour which has come through the coverings of the eye and invaded the orbit, a more thorough clearance of the contents of the latter must be made, and sometimes chloride of zinc is applied as an escharotic dressing.

There is a slightly modified method of division of the muscles which was advocated by Tillaux, but which is not nearly so easy

as the one described above. The external rectus is divided, then the optic nerve; the globe can then be rotated so as to couple the division of the other muscles.

It is surprising how considerable a degree of mobility is attained by the stump on which the artificial eye rests, but many cases leave a good deal to be desired in this respect. A method has been devised to remedy this. The cornea is cut away all round, and all the contents of the globe are emptied, leaving the sclerotic, with the muscles attached, as a sort of shell. Into the sclerotic is inserted a small globular body of celluloid. glass, etc., and the sclerotic and conjunctiva are sewn over this. The method is not satisfactory, as the foreign body frequently irritates or works out, and there have been cases of severe pain or even sympathetic ophthalmia set up by it.

A modification of this is to insert a somewhat larger globe of silver or glass, etc., inside Tenon's capsule, after the eye-ball has been excised by the method first described.

There is no risk of setting up sympathetic ophthalmia if this is used, but, on the other hand, the number of cases in which the artificial eye has worked out is so considerable that most surgeons have given up the attempt to bury a movable foreign body in the orbit.

EXCISION OF THE LACHRYMAL SAC

This operation has of late come into favour as a radical means of dealing with chronic dacryo-cystitis. It is true that it leaves the secretion of tears unaffected, but experience has shown that epiphora is rarely troublesome after the nasal duct has been obliterated by this operation. The chief reasons for its performance are to prevent infective ulceration of the cornea, and to remove a source of danger and annoyance. It should, of course, be limited to those cases in which careful treatment by the usual means has failed.

Mr. F. T. Tooke (*Brit. Med. Journ.*, Dec. 22nd, 1906) records eleven successful cases in an excellent paper on the subject, from which the following brief account is abstracted.

The Operation.—A general anæsthetic is necessary. A veil of sterilised gauze is spread over the face, with an opening large enough to expose the operation area.

Pledgets of sterile wool on small sticks are used as sponges. A curved incision is made downwards and outwards from just above the tendo oculi parallel to the lachrymal crest. This incision goes right through the periosteum to the bone, and extends for an inch. Pressure is made for one or two minutes to check hæmorrhage, and then two self-retaining specula are introduced to hold the wound edges open both vertically and horizontally. These special specula (Müller's and Axenfeld's) may not be to hand, and their place can be well supplied by four stitch retractors, held by an assistant. The periosteum is now carefully retracted forwards over the edge of the crista lacrimalis, and the sac is thus exposed. It is grasped by fixation forceps, and dissected out by means of small curved scissors, aided by a tenotomy hook. The sac is then excised as close as possible to the puncta lacrimalia, and to the beginning of the nasal duct. A fine curette is introduced into the latter, and its mucous lining destroyed. The incision is then completely sewn up after all bleeding has been stopped, and a small dressing applied over the part.

CHAPTER IX

REMOVAL OF TUMOURS OF THE NECK

THE somewhat wide and varied series of operations which could be included under the above title may be very conveniently represented by the operation for the removal of tuberculous glands in the neck. Chapter VII. (Operations on the Thyroid Body) affords an example of a special operation for the excision of a large cervical tumour.

REMOVAL OF TUBERCULOUS GLANDS

These tumours exhibit such infinite variety as regards number, position, relations, and physical characteristics, that their removal will involve a series of surgical procedures extending from an operation of the very simplest character to one which is both complex and difficult.

The trouble to be dealt with may be limited to a single gland, which is well-defined, well-encapsuled, firm, superficial, and more or less free from adhesions to surrounding parts.

Such a tumour, when exposed, " shells out " with the greatest ease, and the operation involved is of the most rudimentary description.

More usually, however, the surgical position lies within less simple lines. The glands are numerous, and are matted together. The more superficial tumours are connected with a string of others which are more deeply placed, and which may extend even to the anterior surface of the spine. These glands are of varying consistence; while some are firm, others are soft, and possessed of so thin a capsule that little force is required to tear them open and allow their creamy and caseous contents to escape.

Not only are they matted together, but they are wedged in among the tissues of the neck, and are fixed by adhesions which, for extent, for toughness, and for their capacity to obliterate

the anatomical details of the part, have few equals in other regions of the body. The surgeon who commences to remove a large collection of tuberculous masses in the neck is setting forth upon no light undertaking, and must at first be uncertain as to the direction in which he will be led, and as to the limit which he may reach.

The number of the tumours is often considerable, and no sooner is one string or cluster removed than another comes into view.

Dangers of the Operation.—The chief dangers in the operation consist in (1) the possible wounding of nerves and (2) of the thoracic duct, (3) hæmorrhage, and (4) the entrance of air into wounded veins.

An operation of this kind should never be undertaken unless the surgeon has perfect confidence in his practical knowledge of the anatomy of the neck.

Scarcely an instance can be cited in the range of operative surgery where a knowledge of structure and of relations is more essential than in these excisions.

1. *Possible Wounding of Nerves.*—The nerves, as a rule, give comparatively little trouble. They stand out well upon the matted tissues, and their isolation is seldom a matter of difficulty.

A nerve may be actually lost in a malignant growth of the neck, but a nerve passing through a coherent mass of tuberculous glands can nearly always be recognised, followed, and isolated. The nerves which usually come in the way of the operation are the ascending and descending branches of the cervical plexus, the superficial cervical being the one most commonly exposed. These nerves may be divided when such division appears inevitable, and no great harm follows. Surgeons differ much as to their treatment of these sensory nerves during the operation. We advocate the most conservative policy possible. Not only may a divided end of a cutaneous nerve become nipped in the scar and cause subsequent trouble, but the operator who is careless as to what is done with these nerves will be apt to divide muscular branches by mistake. Again, a patch of anæsthetic skin, though no great inconvenience, is best avoided.

Hence the rule: *All nerves exposed during the operation, unless of trivial size, should be treated with respect. If divided, the two ends should be sutured together with the finest silk.*

With care they can nearly always be isolated, and drawn aside with blunt hooks from the glands to which they adhere.

Of larger and more important nerves, the one which most frequently comes across the operator's path is the spinal accessory in the posterior triangle. An accidental division of that nerve is very readily effected. One author states that, in removing glands from the neck, he has divided this nerve more than fifty times (*St. Thomas's Hosp. Repts.*, vol. xviii., page 218). He adds that, " although most careful search was made for symptoms due to its division, none could ever be found." From this observation it must be gathered that the nerve divided was the supra-acromial or the outer supraclavicular, and not the spinal accessory. These cutaneous nerves are large, and can readily be mistaken for the motor trunk. If the latter nerve—when exposed—be scratched with the point of the knife, a twitching in the trapezius will always be noticed, no matter how deeply the patient is anæsthetised; and division of the spinal accessory nerve will certainly lead to partial paralysis of the muscle.

Fortunately, both sterno-mastoid and trapezius muscles receive nerve supply from other sources, as well as from the spinal accessory; the former from the second and third, the latter from the third and fourth cervical. Hence complete paralysis of either muscle can hardly occur as a result of an operation for tubercular glands in the neck, even though it has involved section of the spinal accessory. We have known cases, however, in which this latter accident has caused considerable wasting of these muscles, and consequent deformity. It is in the posterior triangle especially that danger to the nerve occurs.

The nerve usually lies over the internal jugular vein, passes under the sterno-mastoid muscle about one inch below the tip of the mastoid process, emerges from the posterior border of the muscle about half-way down, and runs obliquely across the posterior triangle. Parallel to it, but more superficial, is usually one of the main cutaneous nerves.

The next nerves of primary importance are the phrenic, the vagus, and the recurrent laryngeal. It is very rare indeed for

these nerve-cords to enter the field of the operation during the excision of tuberculous glands. Their division or injury in these operations is inexcusable. More than one case has, however, been recorded.

The pneumogastric has been divided without a fatal result. The descendens noni is not infrequently severed. The cervical sympathetic has been wounded in removing a deep-seated tumour which pressed upon the pharynx (*Clin. Soc. Trans.*, vol. xix. page 321). Cases of deliberately planned excision of the cervical sympathetic trunk have proved that no serious harm need result from such an accident. Sarcomata and other tumours have been dissected off the phrenic, the vagus, and the cords of the brachial plexus.

In every case the surgeon must make a most careful examination before operating, with the purpose of ascertaining if any symptoms are present which indicate pressure upon the nerves in the neck; and if such symptoms exist, he must take special care to isolate the nerve or nerves thus individualised.

In removing enlarged glands or other growths—such as lympho-sarcomata—from the root of the neck, two structures must be particularly respected: one is the dome of the pleura, which ascends some distance into the neck, and the other is the thoracic duct. The pleura is readily torn in dealing with a deep-seated and adherent mass.

2. *Wounding of the Thoracic Duct.*—In all operations involving the root of the neck on the left side the danger of wounding or tearing the thoracic duct should be borne in mind. This applies both to tuberculous and to malignant glands. Benetan collected twenty-one cases of this surgical accident, Bergmann quoted seven, and recently Cheyne and Burghard, Fullerton, Deanesley, and Bucknall have recorded cases in their own experience. It will, therefore, be seen that the accident is not very infrequent. Fortunately the belief held in Erichsen's time, that it was always fatal in its results, has been proved erroneous; the great majority of cases have ended in recovery.

Wound of the thoracic duct is dangerous, on account of the possible entrance of air into the jugular vein leading to pulmonary embolism (Schönborn's case, in which the patient recovered

after severe cyanosis and collapse), but still more from the free leakage of chyle from the distal segment of the duct. A small cut through the wall might possibly be repaired by suturing, and W. W. Keen asserts that he successfully joined the two ends of a completely severed duct in this way. Such a proceeding savours of romance, and as a rule occlusion of both ends by ligature has been resorted to with success. Deanesley inserted the distal end into the jugular vein and secured it by suture. Such a course would theoretically be the best to pursue, but the difficulty owing to hæmorrhage from the vein must be extreme. The occurrence of wound of the duct is made known to the surgeon by " a sudden gush of opalescent fluid." After the two ends have been found and ligatured, the distal one becomes much distended with lymph, and there is risk of the ligature slipping or the duct rupturing. Pressure by means of a large sterile sponge should be applied after the neck wound has been sewn up. The patient should be kept perfectly still for some days after the operation, and on a low diet. Vomiting should be guarded against as far as possible.

One thing is certain after wound of the duct, that the surgeon should not trust to pressure by gauze plugging alone, without ligature. In one such case Bucknall (*Brit. Med. Journ.*, Sept. 30th, 1905) was obliged to reopen the wound and tie the duct on the sixth day.

In dealing with gland cases, it is quite possible that the submaxillary salivary gland may be mistaken for a lymphatic tumour, and that its true character may not be discovered until the mass has been cleared for removal.

The parotid salivary gland could scarcely be the subject of such a mistake.

3. *Hæmorrhage.*—The bleeding in these cases may be very free, but it will be nearly always venous.

There is no difficulty in dealing with the arteries; their position is known, and when they are cut a sharp spurt of blood directs the surgeon at once to the bleeding point. The vessel is readily picked up. A word of warning is required with regard to the carotid bifurcation. This may be situated on a level with the hyoid bone, and, owing to dilation of the vessel, in some cases may simulate a gland. As is well known, some

lymphatic glands are always found situated close to the bifurcation.

It is the venous bleeding that is troublesome. The wound is deep, and its depths are not easily illuminated; the blood wells up in a steady and often copious stream, and the details of the operation area are lost.

If the glands are fixed in any given case, it may be taken for granted that they have acquired an extensive hold on the veins of the part, if of no other structures. The lymphatic vessels run mainly with the veins, and this intimate association of the lymphatic tumours and the blood-channels is readily explained.

The veins so involved are found to be enlarged, and tortuous and devious. Sometimes they are stretched over the gland, and are more to be compared to bands of tape than to tubes.

Very often they have been so drawn upon and so extended that they cease to look like veins, and are cut across under the impression that the knife is dealing with a band of connective tissue.

In many cases it is impossible to isolate the vein from the lymphatic tumour, and the vein, if small, has to be sacrificed. The question may easily arise whether it is best to leave a portion of the tumour behind, or remove an inch or so of the internal jugular vein, in cases in which the growth has attached itself to that great trunk. In dealing with tuberculous glands, it is better to spare the vein, to excise as much of the mass as can be removed, and then to pare down what remains with a Volkmann's spoon, until nothing but a fragment of capsule is left clinging to the vein. In dealing with malignant tumours the vein may have to be sacrificed. As a rule ligature of one internal jugular vein has not been followed by any serious result, and exceptional cases have occurred where the vein has been tied on both sides of the neck. If a puncture should have been made into the vein it is as a rule necessary to pass an aneurysm needle round it, and tie above and below the puncture. Sometimes an accidental puncture of the vein has been successfully closed by a fine silk ligature applied without occluding its lumen. Some surgeons in operating on a chain of tuberculous glands more or less adherent to the internal jugular do not hesitate to ligature it high

up, and strip it off the companion artery for some distance, removing it with the glands. A second ligature is, of course, applied below. This introduces a complication which in most cases may cause no trouble, but it is certainly not free from risk, and in nineteen cases out of twenty can be avoided with patience and care in operating. Mr. W. G. Sutcliffe records that in 250 operations for excision of tuberculous glands of the neck he found it necessary to ligature the vein in only four cases.

If a malignant growth has acquired such a hold upon the part as to have completely buried the internal jugular vein in its substance, the circumstances must be very pronounced which would justify a persistent and determined attempt at excision. Early recurrence would be inevitable.

In some cases of extensive tuberculous disease certain of the minor veins, such as the superior thyroid, lingual, or facial, may be so distended as to be for the moment mistaken for the jugular.

In dealing with the lower part of the posterior triangle, the external jugular vein may require to be divided between two ligatures.

4. *Air in Veins.*—In these operations there is some danger of the entrance of air into the divided veins.

It is only necessary here to point out that the accident can only occur in what may be termed dry wounds—wounds cleared of all blood by sponging, etc. The injured vein must either be exposed to the air, or be separated from the air by only a thin layer of blood, before it is possible for air to be drawn into the vein during the act of inspiration. If the wound be full of blood, the accident is impossible. It occurs most usually when a tumour is being dragged from its attachments, or just after a deep incision has been sponged out.

The treatment of the complication is as follows: The moment the hissing sound is heard, the wound should be filled with sterilised water squeezed from a sponge. This at once prevents the entrance of more air. It is useless at the first to attempt to tie the vein. The damaged vessel is not easy to find, and to apply a ligature involves time. Moreover, if the ligature be applied during an inspiration, it would certainly prevent the entrance of more air; but if applied during an

expiration, it would merely prevent the escape of such air as had already entered.

The second step is to endeavour to remove the air that has already entered the chest. This can be best effected by waiting until the next expiratory movement, and then bringing forcible pressure to bear upon the front of the thorax.

The ease with which a large quantity of air can be thus expressed is remarkable, especially in children.

When all air has been expressed, the vein should be seized with pressure forceps and ligatured. The suggestion that air should be sucked out of the right auricle through a catheter passed into the heart through one of the main veins is preposterous. The advice, given in nearly every text-book, that artificial respiration should be resorted to, is almost as silly. There is not too little air in the thorax, but too much.

The Operation.—The patient lies upon the back, with the shoulders very well raised, and with the face turned towards the sound side. The forearm of the affected side is drawn down and secured by the patient's side. The patient's hair and scalp are completely enclosed in an indiarubber cap, or, if this is not available, by a sterilised towel tightly secured. Some moist sterilised packing is wedged in under the nape of the neck, to absorb any blood which may run down in that direction. It is important that the general pose of the part should be such that blood can escape rapidly from the wound and not obscure the movements of the operator. A good light, and at least one good assistant, are necessary.

If the administration of ether leads to marked venous congestion, it may be changed for chloroform or the A.C.E. mixture. The incision must depend upon the site and size of the masses, and must be subject to infinite variation.

In dealing with glands in the upper part of the anterior triangle, the best position for the incision is along the almost transverse skin crease which crosses the neck about the level of the hyoid bone. A fine cicatrix, following this natural fold, may in time become almost invisible. In the lower part of the posterior triangle a transverse incision is also to be advised. Elsewhere the incision may be oblique, and should follow the general line of the sterno-mastoid muscle.

On the ground of the after-appearance, an absolutely vertical incision at right angles to the clavicle cannot be advised. Through a superior transverse incision, and an inferior oblique one, nearly every gland in the anterior triangle can be reached, and in most instances these two incisions are better than a single vertical one of considerable length.

The skin incision must be free, and the success of the operation should never be compromised by attempts to reduce the scar to the minutest possible limits.

The skin, and platysma, and deep fascia are divided.

The sterno-mastoid, when exposed, must be well freed and held aside by retractors. It may be necessary in rare instances to divide part or the whole of the muscle. This should, however, be always regarded as a most exceptional proceeding. Out of 250 cases operated on, even partial division of the muscle was not found necessary in a single one (Sutcliffe). A free division of the muscle may lead to a pronounced form of wry-neck. Glands buried beneath the muscle can be exposed by retractors, or reached through incisions placed on either side of the muscle.

The deep fascia must be divided along the wound, with due care to isolate and preserve any large cutaneous nerves.

When the mass of glands is reached, they may be found to be non-adherent, and to be capable of being "shelled out" with perfect ease.

As a rule, however, these glands are adherent, and the surgeon's first care must be to find out the least adherent side of the tumours or tumour.

He must take care that his dissection has extended down to the very capsule of the gland, and the rule repeatedly insisted upon by the late W. Knight Treves, in his many papers upon this subject (*Lancet*, 1888 and 1889), that throughout the whole operation the surgeon must keep close to the capsule, cannot be too accurately observed.

As soon as a little clearing has been effected, the surgeon introduces his finger and seeks for the least fixed part or parts of the tumour. It is from these less adherent sides that the growth is attacked.

It is well that it should be approached from more sides than

one. In digging out, as it were, the fixed gland, the scalpel will be considerably assisted by blunt-pointed scissors curved on the flat.

A most useful instrument, however, in this part of the operation, is a simple old-fashioned periosteal elevator of small size.

By means of this instrument the tissues over the gland may be peeled off, adhesions may be separated, and the gland be lifted out of its bed. Another useful instrument at this stage is Cooper's hernia director, which is round-pointed and more slender than the elevator, but which is, however, used rather as an elevator than as a director.

A large number of special elevators and forceps for seizing the glands have been devised, but it would serve no purpose to describe them here. Kocher's and Greville Macdonald's elevators are two varieties as useful as any. There is no forceps yet invented that will hold a tuberculous gland securely without rupturing it.

The clearing of the gland must be carried out gradually, and the process is tedious enough.

It is unwise to attempt to tear the mass out. If this be done, the gland will either break up and its softened contents escape, or a nerve to which it is adherent may be ruptured, or a part of the wall of a large vein be torn right away. Before a strand or bridge of tissue is divided, it should be relaxed a little, so that its true nature may be perceived. A vein put much upon the stretch may look like a band of connective tissue. If a layer of tissue, to be divided, be drawn up from the depths of the wound, it is well not to cut it at once while it is on the stretch, but first to relax it a little, so that its character may be better appreciated. In this stage of the excision the main axioms should be—keep close to the capsule; make no cut in the dark; be chary of cutting tissues which are only seen when put fully upon the stretch.

In process of time a kind of pedicle to the once adherent glands will be formed, and when this has been reduced to its smallest limits it should be held by two fenestrated artery forceps, and divided close to the glands. It may or may not

contain vessels which require a ligature. In any case the forceps will prevent the stump from dropping out of view, and in general terms it may be said that the inclusion of a large pedicle of uncertain composition within one ligature is to be condemned.

Every care must be taken to avoid wounding veins unnecessarily. Many have to be cut, and should in all cases be at once secured with a ligature, or with pressure forceps. With properly sterilised thin catgut there can be no fear of the sutures giving trouble, and it is best to apply one to every severed vessel of any size. It is, however, surprising how quickly and easily the bleeding is checked so soon as the glands are removed and the traction released.

The greatest difficulty occurs when a large adherent vein has been opened by tearing. In such a case an inch or more of one side of the vein may have been removed. Pressure forceps avail little. The vein must be isolated, and secured above and below the rent.

Care must be taken not to tear or wound the gland capsule. If this has been done the purulent or caseous contents escape, or the soft gland substance is squeezed out. The firm tumour becomes a flabby bag, the depths of the wound are obscured, and the removal of the collapsed gland is difficult. In such a case the capsule must be carefully dissected and scraped away, piece by piece, after the gland has been evacuated, and the wound well cleared out.

Now and then it may be found impossible, or at least very unwise, to complete the excision of a deep-seated gland. The surgeon must have good grounds for coming to this conclusion. The glands which have to be abandoned are exceedingly few, and neither lack of knowledge nor lack of perseverance should form bases for this determination. The gland so placed must be evacuated and cleaned well out with the sharp spoon. The capsule must then be dissected away as completely as is possible, and what tissue remains must be reduced to the smallest possible proportions by a further diligent application of the sharp spoon. We have found this measure to answer well, to place no obstacle in the way of primary union, and usually to lead to no further trouble.

The removal of the gland, however, with its capsule entire, is by far the most satisfactory measure.

The deep wound left by the operation may be flushed out with warm saline solution, and every trace of bleeding must be checked.

Pressure with a sponge is the most effectual measure for minor hæmorrhages.

The wound may now be closed. Small blunt hooks are introduced in the manner already described (page 48, vol. i.) in order to ensure accurate approximation of the edges.

Silkworm gut is by far the best suture material. The threads are all introduced, and before the first one is tied the surgeon must satisfy himself that the wound is still clear of clots. The highest sutures are secured first, and as they are tied the assistant follows the closing wound with a sponge, which should be so firmly pressed upon the part as to obliterate the wound cavity. In all cases in which the operation has been extensive, and the wound deep, or in which there has been much bleeding, or portions of tissue have been left behind, it is well to introduce a drainage-tube. This tube may be removed at the end of twenty-four hours. The attempt to dispense with the use of a drainage-tube rarely succeeds, especially if the operation has involved much manipulation of or traction on the tissues. If it is not inserted, serum or blood will probably collect, and will distend the wound, and cause trouble. A small rubber tube (spiral or otherwise) is, therefore, a necessary precaution.

The usual dressing is applied of sterilised gauze, packed round with cotton-wool. The pressure applied while the sutures are being secured must never be relaxed, and the dressing must be made to press firmly upon the part. The bandage, to obtain a good hold of the neck, must usually be carried beneath the axillæ, and certainly over the head.

The pressure brought to bear upon the wound may cause some blueness of the face until the effects of the anæsthetic have passed off. This interference with the venous current from the head may possibly delay the recovery from chloroform.

If the patient has very enlarged tonsils, the operation should not be attempted until the tonsils have been removed,

because a properly firm dressing can seldom be applied in such a case without producing symptoms of suffocation.

The **after-treatment** of these cases calls for little comment. The firm dressing, the collar of cotton-wool, and the elaborate bandaging, keep the neck stiff. In children the part may be maintained more completely at rest by fixing the head in a loosely filled sand-bag. Rest of the part is most essential, and should be observed with the utmost rigour for seven to ten days—that is to say, if primary healing with the minimum amount of scarring is desired. The child should not be encouraged to talk, and all its food should be soft or fluid, so that the muscles of mastication may be used as little as possible. The drain should be removed at the end of twenty-four hours, and the sutures between the sixth and the eighth day. A small dressing of gauze and collodion or celloidin solution is very convenient after the first few days, as in the case of most wounds about the head and neck. The celloidin solution is made as follows: Celloidin, 5 parts; ether and ethylic alcohol, of each 15 parts. It dries more rapidly, and forms a better pellicle than collodion, but contracts more firmly, and may thus pucker the skin.

Comment on Special Cases.—We have advised a conservative course as regards the internal jugular vein, but it should be noted that Sir. W. Watson Cheyne has urged that removal of a large part of this vein with the lymphatic glands is harmless, and almost to be recommended as a routine measure. He also attaches importance to the application of pure carbolic acid to any sinuses or scraped gland-cavities. Mr. H. J. Stiles (*Brit. Med. Journ.*, Sept. 12th, 1896) supports both these contentions. We differ emphatically, believing that the free application of carbolic acid is a risky procedure, and can do no real good. As regards early ligature of the internal jugular, with its removal, we agree with Mr. Sutcliffe that this is a gratuitous complication.

An important variety of tuberculous deposit in the neck should be noted, as it may cause disappointment as regards the result of the operation. A caseating gland, deep below the fascia, may have perforated the latter, and produced a tubercular focus superficial to it. The operator may mistake this for the gland;

it is necessary to open up the hole in the fascia, and to attack the deep gland.

Especial care should be taken in dealing with tubercular glands in front of the ear—the pre-auricular set—as Steno's duct and the facial nerve may be endangered. It is hardly necessary to point out that not all cases of tubercular glands in the neck are suitable for operation. In some extensive bilateral cases other measures, including the trial of Wright's vaccine method, are indicated. Occasionally it will be best to operate first on one side of the neck, and, on a later occasion, on the other.

CHAPTER X

EXCISION OF THE TONGUE

THIS operation may, of course, be complete, or it may be partial—limited, say, to one side of the organ or to the anterior half. It is not worth while to discuss here very limited excisions, such as may be employed for wasting growths, or even for some cases of leukoplakia or ulcers

The major operation of excision of the tongue is almost always performed for cancer, occasionally for sarcoma, which is, however, an exceedingly rare occurrence in this position.

Cancer of the tongue is most usually situated on the dorsal aspect, and is especially common at the margin of the organ. It is comparatively rare on the under surface or at the tip.

An excellent epitome of the history of the operation has been furnished by Woelfler, and elaborated by Mr. Barker ("Holmes's System of Surgery," 3rd edition, vol. ii., page 597. 1883). From this it appears that Pimpernelle, who died in 1658, was probably the first to excise the tongue with success. Guthrie (in 1756) is stated to have been the first English surgeon to excise a cancer of the tongue, using the knife and cautery.

The Various Methods of Operating.—The following facts are derived from Woelfler and Barker's epitome :—

The Ligature.—The removal of the tongue by strangulation with a ligature was carried out by Inglis (1803) and others. The organ was usually split, and a ligature applied to each half. Cloquet (1827) introduced the ligature through a suprahyoid incision.

The Écraseur.—This instrument was introduced by Chassaignac in 1854, and has been extensively employed. It has been used through the mouth, or introduced through a suprahyoid incision after Cloquet's method. Both the cold wire and the galvanic écraseur have been made use of.

Although the ligature, the galvanic and the cold wire écraseur have been used within the last twenty or thirty years, they must be regarded as now quite obsolete. Excision by means of scissors,

as advocated by Whitehead (1877) and others, has entirely superseded such methods.

Preliminary Ligature of the Lingual Artery was introduced by Mirault in 1833. The method has been employed by Roux and Roser, and has been within more recent times revived by Billroth.

Division of the Cheek.—This was carried out by Jaeger in 1831, in order to obtain freer access to the tongue. Maisonneuve (1858) and Collis (1867) advocated and employed this method.

Division of the lower jaw has been effected to obtain a ready access to the tongue and the floor of the mouth. The method was introduced by Roux in 1836, and has been carried out and modified by Sédillot (1844), Syme (1857), and Billroth (1862).

During the last few years Professor Kocher has again revived Roux and Syme's method.

The inframaxillary incision was first employed by Regnoli in 1838. The tongue was reached by an incision along the border of the lower jaw.

This method has been employed and developed by Czerny (1870), Billroth (1871–6), and Kocher (1880).

Circumstances of the Operation and the Question of Hæmorrhage.—The main difficulties encountered in attempting to remove the entire tongue are dependent upon the narrow space in which the operation has to be performed, and upon hæmorrhage.

To get over the first difficulty ingenious gags have been invented, and various cheek retractors employed, or the cheek itself has been slit up, or the jaw divided, or the mouth entered by an incision in the suprahyoid or inframaxillary region. It is recognised that the excision, to be satisfactory, must be complete, and to effect this the surgeon's movements must not be hampered.

We have no hesitation in saying that the inframaxillary incision, which involves a communication between the neck wound and the cavity of the mouth, can be very rarely required, and should, if possible, be avoided. The gravity of the operation is much increased by it, as may be judged from the fact that Professor Kocher, who advocated it for long, has entirely abandoned it in favour of division of the jaw.

With regard to this, also, we see no reason for its adoption. If the mouth is well opened by a gag, the whole tongue and floor

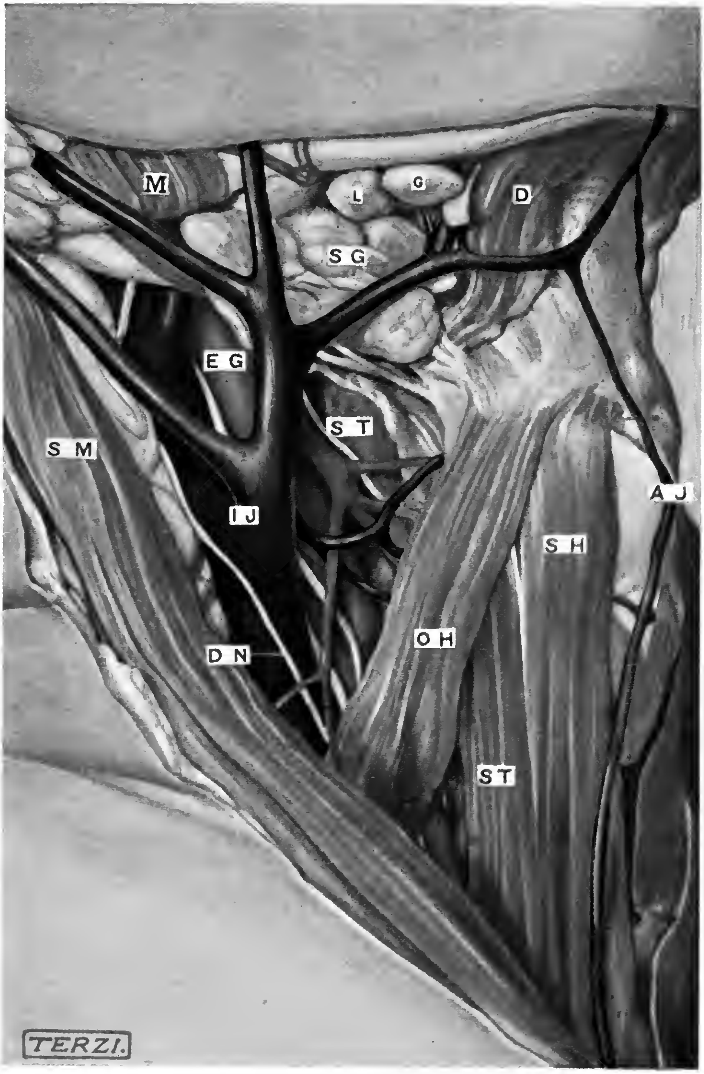

PLATE XIX.—ANTERIOR TRIANGLE OF THE NECK.

(From a Dissection in the Museum of the London Hospital Medical College.)

THIS PLATE IS DESIGNED SPECIALLY TO SHOW THE PARTS MET WITH IN THE RADICAL OPERATION FOR CANCER OF THE TONGUE, AS WELL AS THAT FOR REMOVAL OF TUBERCULOUS GLANDS BESIDES THE LYMPHATIC GLANDS IN THE SUBMAXILLARY TRIANGLE (L.G.), OTHERS ARE SHOWN ALONG THE ANTERIOR BORDER OF THE STERNO-MASTOID MUSCLE (S.M.) AND UNDER ITS EDGE. ONE LARGE AND IMPORTANT GLAND IS ALWAYS PRESENT BEHIND THE ANGLE OF THE LOWER JAW, REACHING UNDER THE PAROTID GLAND. I.J., INTERNAL JUGULAR VEIN RECEIVING ABOVE THE FACIAL BRANCH AND A COMMUNICATING BRANCH FROM THE TEMPORO-MAXILLARY VEIN. E.G, EXTERNAL CAROTID ARTERY. THE UPPER S.T., ITS SUPERIOR THYROID BRANCH, CLOSE TO WHICH IS THE EXTERNAL LARYNGEAL NERVE. D.N., DESCENDENS NONI NERVE, SUPPLYING O.H., OMO-HYOID MUSCLE. THE LOWER S.T. AND S.H., STERNO-THYROID AND STERNO-HYOID MUSCLES. A.J., ANTERIOR JUGULAR VEIN. S.G., SUBMAXILLARY SALIVARY GLAND. D., DIGASTRIC MUSCLE ANTERIOR BELLY). M., MASSETER MUSCLE.

of the mouth are accessible, and in exceptional cases the cheek may be split to increase the aperture.

The amount of *hæmorrhage* in excision of the tongue varies greatly according to the method employed.

Some surgeons deal with the tongue alone, after Whitehead's directions. Mr. H. T. Butlin advocates a second operation for removal of submaxillary and lymphatic glands of the neck about a fortnight afterwards. In either case the tongue is excised with scissors, and the lingual arteries secured just before they are cut in the mouth. As a rule the hæmorrhage is thus easily controlled, but the bleeding may be very troublesome.

We strongly recommend preliminary ligature of the vessels in the neck, before the tongue is dealt with. The lymphatic glands are dissected out, both lingual and facial arteries secured, and the tongue excised as the final stage of the one operation. If this be performed, the actual excision of the tongue is a rapid and bloodless procedure. There are many advantages, both to the patient and to the operator, in performing the whole operation at once, and not dividing it into two, each requiring a general anæsthetic.

Extent of the Operation.—When the extreme tip of the tongue is involved, the part may be excised by a **V**-shaped incision, the base of the **V** including the tip of the organ, the apex being at the middle line, some distance from the tip.

The margins of the triangular gap thus left may be approximated by sutures.

If a large part of the tongue is removed, sutures may sometimes be useful to diminish the raw area, but the attempt to shape the excision so as to effect complete suture is usually unwise. The essential thing is to cut wide of the growth *all round it*, and in most cases, when they come for operation, the extent of the cancerous growth does not allow of such limited excision.

It should also be remembered that sutures placed in the tongue always become septic, and should never be inserted so as to produce tension.

Cancer, in the great majority of cases, commences on the lateral aspect of the tongue. Whilst it is still confined to one side of the middle line there is no valid reason for removing the

whole organ. Supposing it has infiltrated the anterior portion on both sides, the surgeon may often safely leave a stump formed of the posterior third or less. If the whole tongue be excised, the floor of the mouth will ultimately project upwards and take its place to a surprising extent, but articulation is never so good as if a fair-sized stump has been left, and the constant flow of saliva may prove a nuisance to the patient. The general rule may be laid down, to cut wide of the cancer, but leave any perfectly healthy part of the tongue. Recurrence is common in the lymphatic glands, rare in the stump of the tongue.

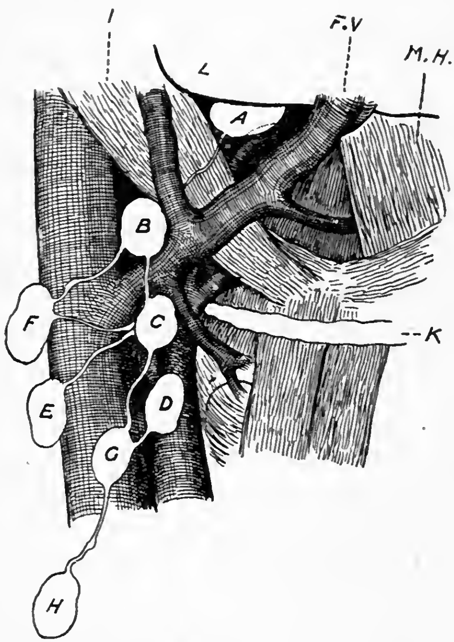

FIG. 296.—THE LYMPHATIC GLANDS ESPECIALLY CONCERNED IN EPITHELIOMA OF THE TONGUE.

A, Gland in submaxillary triangle (the submaxillary salivary gland has been removed); B to H, Glands over internal jugular vein, its junction with the facial, over the carotid artery, and behind jugular vein; I, Digastric muscle; M.H, Mylo-hyoid; F.V, Facial vein; L, Jaw; K, Hyoid bone.

The particular lymphatic glands which are the dangerous ones with regard to cancer of the tongue may be defined with fair accuracy; they are shown in Fig. 296.

There are one or two lymphatic glands placed in the submaxillary triangle amongst the lobules of the salivary gland, but these are rarely involved in cancer of the tongue. Cancer of the lower lip, however, frequently infects these. If the primary growth in the tongue extends far back towards the tonsil, the gland marked A, situated under cover of the jaw, is liable to be infected.

But in the great majority of cases the carcinoma starts on the lateral aspect of the tongue, and deposits occur in the glands outside the submaxillary triangle at the junction of the facial and jugular veins, on the outer aspect of the carotid bifurcation,

along the course of the main vessels and beneath the deep fascia (B, C, D, G, in Fig. 296). Later on, the glands at the back of the jugular vein (F, E), or even those lower down (H, etc.), become involved. As they soon adhere to the main vessels, their removal at a later stage becomes difficult and dangerous. Hence the operation for excision of cancer of the tongue should include at the same time a careful and thorough attempt at removal of the lymphatic glands referred to on one or even on both sides of the neck.

If the epithelioma is confined to one margin of the tongue, the question arises whether it is necessary to remove the lymphatic glands on both sides of the neck. It is undoubted that the lymphatic vessels of the tongue communicate, and occasionally glandular recurrence has followed on the opposite side of the neck to the partial tongue excision. Nevertheless, if the growth is wholly unilateral, and not apparently infiltrating much, it seems reasonable to limit the neck operation to that side.

If the growth infiltrates deeply, it is essential to clear away the lymphatic glands on both sides of the neck.

Should the Submaxillary Gland be Removed?—As already noted, cancerous deposits in this gland rarely accompany epithelioma of the tongue, though the submaxillary gland often is harder than normal owing to a degenerative sclerosis. Its removal complicates the operation to no great extent, but involves ligature of the facial artery and vein, and therefore prolongs the operation. If the primary growth encroaches on the floor of the mouth, it is certainly best to clear the submaxillary triangle, but the mylo-hyoid muscle should be left, to prevent the neck and mouth wounds from communicating.

The late M. Poirier, of Paris, well known for his advocacy of radical operations for lingual cancer, was strongly in favour of this course. When the mylo-hyoid muscle is actually invaded by growth from the floor of the mouth it must, of course, be excised, but the prognosis of such operations is so bad that they are hardly worth doing.

Some surgeons, amongst them Mr. Butlin, advise that the tongue excision should first be carried out, and that the second operation on the glands of the neck should be performed a few weeks later. This course has the disadvantage of submitting

the patient to two serious operations at a short interval, and, moreover, loses the advantage of preliminary ligature of the lingual arteries. Provided that the latter vessels have been secured in the neck, a free excision of the tongue may be carried out quickly and with hardly any bleeding, and there is no risk of secondary hæmorrhage.

I. EXCISION WITH PRELIMINARY LIGATURE OF THE LINGUAL ARTERIES, AND REMOVAL OF THE LYMPHATIC GLANDS LIKELY TO BE INVOLVED

Preliminary Measures.—For some days before the operation every attempt should be made in cancer cases to overcome the foul state of the mouth. For this purpose a wash of carbolic lotion (1 in 80) may be used hourly, and especially after any food has been taken. Frequent use of tooth-brush and antiseptic dentifrice should be insisted on. All carious or loose teeth should be removed, if possible, a few days before the major operation is done. The incisor teeth in cancer cases are often loose, uncovered by the gum, and foul with tartar.

Better results would be obtained if a moderate amount of care were taken to render the mouth less septic. It is unwise deliberately to carry out any excision in an atmosphere of putrefaction.

The patient's neck and face must be shaved.

Instruments required.—Mouth gag; curved needle in handle; tongue forceps; mouth retractor; blunt-pointed scissors, straight and curved; volsella; Wells' pressure, dissecting, and fine-toothed forceps; sponges in holders; ligatures, etc.; scalpels; retractors; blunt hooks; aneurysm needle; needles and silkworm-gut sutures.

The instruments required for the first stage—including ligature of the lingual and dissection of the glands—should be in one dish, whilst those required for the second stage—the actual excision of the tongue—should be kept in a separate dish.

The best gag is Mason's or Hewitt's. It must be strong, and the blades be capable of wide separation. The "catch" fixing the gag when open must be secure. A "catch" is better than a screw.

The best cheek retractor is the broad rectangular retractor used in nephrectomy operations. It is in every way excellent.

The scissors used for cutting out the tongue should be straight, or slightly curved on the flat. They should be longer than the usual pattern, and should end in square blunt points. The cutting edge should extend up to the very tip.

We will suppose that the case to be operated on is an extensive one, and that the surgeon must deal with the lymphatic glands on both sides of the neck, and must also remove nearly the whole tongue.

Position.—The patient's head and shoulders are well raised in an even slope. This position diminishes venous congestion and makes it easy for the operator. The patient's head should be turned towards one side, and the chin kept raised by the anæsthetist. The gag is not introduced at first, but it is often useful to introduce a loop of suture through the mid-line of the tongue; the loop is held in a Wells' forceps, and traction made if the breathing should become poor.

We would emphasise the pronounced upward slope of the patient's neck and thorax, the chin held steadily raised. Of course, care must be taken lest the non-sterile hand of the anæsthetist should touch the wound, etc., during the operation. The anæsthetist stands at the head of the table, and by him an assistant, who will sponge or retract and will subsequently hold the gag.

A good light is essential.

The Operation.—A curved incision is made from just below the angle of the jaw towards the symphysis; it extends downwards to the hyoid bone (Fig. 297).

A second, nearly vertical, cut is made along the anterior edge of the sterno-mastoid muscle for three inches.

Both incisions are made through skin and platysma muscles, and then more deeply through the fascia.

The edge of the sterno-mastoid muscle is cleanly exposed for many inches, with the carotid artery and jugular vein. Through the upper curved incision going through platysma the outer surface of the submaxillary gland is bared up to the border of the jaw. The lower border of the gland is now dissected so as to expose the facial vein, which is ligatured and divided.

More deeply, and much higher up, the facial artery is sought for coming from under the digastric muscle, and is also tied and divided. The whole of the submaxillary gland, and the adjacent lymphatic glands, are now dissected out and removed, Wharton's duct being ligatured (to prevent possible contamination of the wound by backward flow of saliva). Several vessels will require clamping besides the distal ends of the facial artery and vein, where these mount over the jaw. The submaxillary triangle has now been emptied. The surgeon next dissects off with caution the whole group of lymphatic glands lying over the jugular vein and carotid artery (those shown in Fig. 296). It is important to remove a large gland somewhat under cover of the parotid, and, as Mr. Butlin has pointed out, no harm results if a part of the salivary gland itself is excised.

FIG 297.—INCISION FOR REMOVING SUBMAXILLARY AND LYMPHATIC GLANDS, AND FOR TYING LINGUAL ARTERY, PRELIMINARY TO EXCISION OF TONGUE.

The wound somewhat resembles the capital letter Y. The three flaps are held aside by suture retractors.

In dissecting the glands from the large vessels the blunt dissector will be found invaluable.

Such glands as can be found at the posterior edge of the vein should be removed, and the lower down the neck this dissection is carried out the better. But it may again be mentioned that the really dangerous glands are those grouped round and over the main vessels from the angle of the jaw above to the cricoid cartilage below (those shown in Fig. 296).

This is the most tedious part of the operation, but at the same time the most important. The removal of glands being completed, it is now easy to secure the lingual artery. The tendon

of the digastric muscle is drawn downwards with a blunt hook, the posterior edge of the mylo-hyoid is defined, and the hypoglossal nerve with the ranine vein is seen passing beneath it.

With blunt dissection the nerve and vein are displaced slightly upwards, particular care being taken not to wound the vein. In the small triangle formed by the nerve, the posterior belly of the digastric, and the posterior border of the mylo-hyoid, the surgeon now incises the hyo-glossus fibres which form its floor. This is done cautiously, the muscle fibres being fixed by fine-toothed forceps. It is easy to go too deeply and wound the lingual artery, or perhaps to miss it and work in too deep a plane. As a rule, provided that the points mentioned are carefully observed, the artery is found with ease. An aneurysm needle is passed from below round the artery, and the latter securely tied. All bleeding points are secured by catgut ligatures, and the wound is quickly sewn up with silkworm gut. It is advisable to leave a small drainage-tube in the lower angle of the wound.

A moist aseptic pad or large sponge is now placed over the wound, and the patient's head turned so as to rest on this pad, whilst the operator repeats the dissection. All the difficult and tedious part of the operation is now over. In uncomplicated cases both sides of the neck may be cleared in the manner described in about an hour, very rarely less. The lingual and facial arteries on both sides have been secured, both wounds have been sewn up, with provision for drainage, a temporary dressing has been secured around the neck, the instruments previously required are put aside, and the anæsthetist arranges to give chloroform through Junker's inhaler with a metal tube (or by means of Hewitt's gag).

The operator stands on the right side of the patient, the gag being inserted on the left. The assistant must be provided with plenty of small pieces of sponge mounted in holders, and the position of the gag must be carefully supervised—otherwise it is apt to slip forward. The instruments must be placed within easy reach of the operator, who will usually find it convenient to stand on a stool, so that he can look down into the back of the patient's throat. When the gag is opened it often happens that the breathing becomes obstructed and the patient

somewhat cyanosed; this condition should be relieved by traction on the tongue, made with the ligature and by holding the jaw forwards.

With volsellum forceps in the left hand and scissors in the right, the operator now excises the affected area of tongue. He must divide the mucous membrane at a considerable distance from the edge of the epithelioma, and continue the incision so that a large margin of healthy tongue is removed with the growth. Sometimes, as we have said, it is necessary to remove the entire organ, in other cases only one half; in some a wedge-shaped piece is removed. The bleeding, if the lingual arteries have been secured, is mainly venous and insignificant in amount. Wells' forceps should be applied, in case any vessel spurts. By turning the patient's head on one side, and by careful sponging, the blood should be entirely prevented from running down the throat.

When the surgeon is satisfied by inspection that all hæmorrhage is arrested, and that the growth has been freely excised, the gag is removed, The neck dressing is again seen to, and a piece of macintosh secured over it, so as to prevent it from being soiled.

Until the patient comes round from the anæsthetic, he should be kept lying somewhat on the side, and a nurse should use a mounted sponge from time to time in the mouth. When he has come round the head and shoulders should be well supported by pillows, as venous oozing will be diminished by this means.

Comment.—With regard to obtaining free access to the mouth during the excision, the gag and cheek retractor usually suffice. The gag should be on the side away from the growth when the latter is unilateral. If these measures are not sufficient, and especially if the epithelioma encroaches on the jaw, the cheek may be split and subsequently sutured. Invasion of the alveolar margin may necessitate excision of part of the bone by chisel and gouge, together with removal of the sublingual gland and other soft parts at the floor of the mouth.

As regards the preliminary incisions in the neck, we have found the one described answer admirably for exposure of the glands, etc., but various modifications are in use. Poirier's incision runs along the anterior border of the sterno-mastoid, from the

level of the jaw nearly to the sternum ; this is joined at right angles by a second one from the symphysis. Reference to Fig. 297 will show that this is practically identical with ours.

Some surgeons recommend that the external carotid should be tied, instead of its branches, the facial and lingual. But ligature of these two arteries ensures perfect hæmostasis in the mouth. Mr. H. T. Butlin recommends a double operation : first, excision of the tongue with laryngotomy, followed a fortnight later by operation on each side of the neck. We have given reasons for preferring the single operation without laryngotomy, but Mr. Butlin's opinion is of much weight.

The method described above combines the advantages of preliminary ligature of the lingual arteries with excision of the lymphatic glands most likely to be involved by epitheliomatous deposit. When recurrence takes place after excision of the tongue, it is usually met with not in the stump, but in the glands. At the time of operation it will frequently be found that glands which lie under the sterno-mastoid, and which could not be plainly felt, contain small secondary deposits. Nevertheless, some surgeons prefer to excise the tongue without preliminary ligature or dissection in the neck. The following description is based on Mr. Whitehead's account.

2. EXCISION WITHOUT PRELIMINARY LIGATURE

A firm ligature is passed through the anterior portion of the tongue for the purpose of traction. Much depends upon the care of the assistant to make the traction in the right direction and at the right time.

The first step in the actual operation consists in the separation of the tongue from its attachment to the floor of the mouth and the anterior pillars of the fauces. The ease with which the operation is continued depends largely upon the freedom with which this separation is carried out. The two structures principally responsible for the retention of the tongue within the mouth are the frænum and the anterior pillars of the fauces ; and if these are completely divided in the first instance, the tongue may be so freely drawn from the mouth that the operation is practically converted into an extra-oral excision. "Extended practice," writes Mr. Whitehead, "has made me conduct this part of the operation with less deliberation and more rapidity than was my habit in my earlier cases. Instead of

the cautious snipping I originally advocated, I now boldly cut until I get close to the vicinity of the main arteries, disregarding all bleeding, unless an artery distinctly spurts, when I twist it and proceed. The more profuse the general oozing, the more rapidly I proceed, my object being to get as quickly as possible to the main arteries, as I have confidence that all subsidiary bleeding will cease immediately after their division. There is, in reality, no difficulty in determining the actual position of the lingual arteries, as they are practically invariably found in the same situation, and it requires very little experience to seize them with a pair of forceps before dividing them ; if this be done there need not be the slightest hæmorrhage from this source. When once the vessels are effectually twisted, the rest of the tongue may be removed without any further anxiety about hæmorrhage ; but it is desirable, before finally severing the last attachments, to pass a loop of silk through the glosso-epiglottidean fold, as a provisional measure of security, in case it may become necessary to make traction on the posterior floor of the mouth, either to assist respiration, or to arrest any possible consecutive hæmorrhage. Traction on this ligature of itself arrests hæmorrhage, and makes it an easy matter to secure any bleeding vessel. As the retention of this ligature is a source of some annoyance to the patient, I always remove it at the end of twenty-four hours." Strong, straight, blunt-ended scissors are employed.

After the tongue is removed, the floor of the mouth is washed with a solution of biniodide of mercury (1 in 1,000), is well dried, and is then painted with an antiseptic "varnish" introduced by Mr. Whitehead. This varnish contains the ordinary ingredients of friar's balsam, and differs from it in the fact that for the rectified spirit is substituted a saturated solution of iodoform in ether. With the ether is mixed one volume in ten of turpentine. This varnish dries immediately, and leaves a firm coating on the wound which lasts for twenty-four hours, and produces no irritation. It also acts as an admirable styptic.

Some surgeons simply dust the floor of the mouth with iodoform. Others resort to the objectionable practice of stuffing the mouth, or at least the lower segment of it, with gauze. We have dispensed with applications of any kind. The mouth is well washed out with an antiseptic lotion, and is left. It must be remembered that the discharge of saliva is fairly copious, and renders any "dressing" almost immediately ineffective.

Comment.—We think that the ligature left in the glosso-epiglottic tissues may well be dispensed with, provided both linguals have been secured. As recurrence in the lymphatic glands is to be expected soon, a second operation to remove them should be performed later.

When the disease involves the frænum, it is well—as Mr. Jacobson points out—to extract two or three of the lower incisors. If this be not done, it is very difficult to obtain a clear field for the scissors, and a complete excision of the implicated tissues may be found to be almost impossible.

3. EXCISION OF THE TONGUE THROUGH A SUBMAXILLARY INCISION

This method was first described by Kocher in 1880 (*Deuts. Zeitschr. f. klin. Chir.*, Bd. xiii., page 147), and has been especially advocated in England by Mr. Barker. Professor Kocher has, however, entirely abandoned the method known by his name, in favour of Syme's operation (median division of the lower jaw followed by excision of the tongue. *See* Kocher's "Operative Surgery," 1902 edition).

The patient having been placed in position, a preliminary tracheotomy is performed.

An ordinary cannula is employed, and the pharynx is plugged with a clean sponge, which has been wrung out in carbolic lotion, and to which, as a security, a long silk thread is attached.

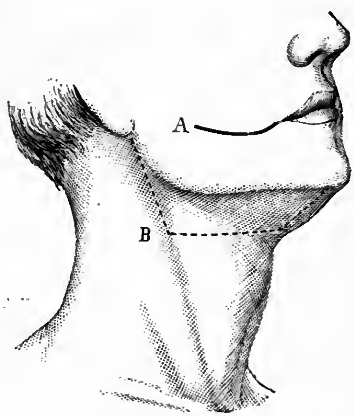

FIG. 298.—REMOVAL OF THE TONGUE.
A, Incision for splitting the cheek; B, Kocher's incision.

The mouth will have been already as well cleansed as is possible, and should have been very frequently rinsed out with some antiseptic solution.

Chloroform is administered through the tracheal tube.

An incision is made in the neck. It commences just below the lobule of the ear, and runs along the anterior border of the sternomastoid muscle.

When the middle of this border of the muscle has been reached, the incision is carried forwards to the hyoid bone, and thence to the symphysis along the anterior belly of the digastric muscle (Fig. 298).

The flap thus marked out is turned upon the cheek. The facial vessels are ligatured, as is also the lingual artery before it passes beneath the hyo-glossus muscle. The submaxillary fossa is now evacuated, the surgeon working from behind forwards. All the lymphatic glands

of the region are removed, and also the sublingual and submaxillary salivary glands, should the diseased tissue be in near association with them. The mylo-hyoid muscle having been cut through as far as is needed, the mucous membrane is divided close to the jaw, and the tongue drawn out through the opening.

The tongue may now be slit in the middle line, and one half removed with scissors.

If the whole tongue needs to be removed, the lingual artery of the opposite side must be ligatured through a separate incision.

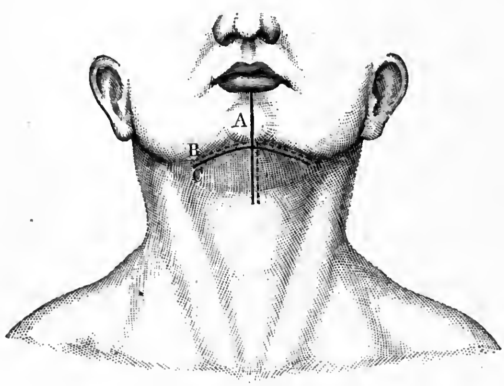

FIG. 299.—REMOVAL OF THE TONGUE.
A, Incision of Roux, Sédillot, Syme; B, Regnoli's incision; C, Billroth's incision.

The skin incision is not closed by sutures, but the whole wound is left open, and its cavity plugged with gauze or with a sponge wrung out in carbolic lotion.

The wound is allowed therefore to close by granulation, while the freest possible vent is provided for the escape of all discharges. The tracheotomy tube is retained until the wound is granulating healthily. It thus happens that the patient breathes fresh air throughout the most important period of the after-treatment, or, at least, the air inspired has not passed through the mouth and over the wound surface.

Comment.—This operation has the great drawback of a large wound in the neck, into which saliva and septic discharges soak for some days, and the tracheotomy in itself is an addition to the operation of excision of the tongue which should and can be dispensed with in the great majority of cases. The mortality of the operation even in the most practised hands has been heavy.

4. EXCISION AFTER DIVISION OF THE LOWER JAW

This is the operation of Roux, Sédillot, and Syme. The soft parts are divided in the median line by an incision which bisects the lower lip, traverses the chin, and ends at the hyoid bone (Fig. 299, A). All bleeding having been arrested, one of the lower central incisors

is extracted, and two holes are drilled through the jaw below the level of the teeth, each hole being about a quarter of an inch on either side of the median line.

The jaw is now divided as near to the middle line as possible. The section may be vertical, or may be slightly serrated, so that after the excision the two portions of the jaw may be to some extent interlocked.

The two halves of the jaw are held asunder by assistants while a stout silk ligature is passed through the tongue, and by means of this thread the organ is drawn well forwards and upwards.

The floor of the mouth is opened up. The mucous membrane between the tongue and the alveolus is divided with scissors ; the genio-hyoid and genio-hyo-glossi muscles are then cut with the same instrument.

The excision of the tongue is carried out with the scissors. The tissues entering the under surface of the tongue are divided in order from before backwards, and all bleeding vessels are at once secured. The operator should endeavour to ascertain the position of the lingual arteries, and each artery may be grasped with pressure forceps before the section is carried beyond the vessel. It is well that one artery should be secured before the other is cut. It is better to conduct the operation slowly, and to proceed step by step, rather than to attempt to slash the tongue away boldly by one or two vigorous cuts with a bistoury.

A very convenient plan is to split the tongue, and remove one half at a time. While the first lingual is being dealt with, the tongue is held forwards by means of the intact half ; and while the second artery is being dealt with, the stump may be drawn forwards by the forefinger, which is hooked, as it were, in the pharynx.

As much of the tissues in the floor of the mouth as appears to be involved must be removed.

Bleeding arteries should be secured by torsion rather than by ligature.

The two halves of the jaw are wired together by a stout silver wire passed through the two holes.

The wound is closed by sutures, and a drain is introduced into its lower angle.

A gutta-percha cap may be fitted to the chin to prevent displacement of the divided bone.

Precautions should be taken to prevent the falling back of the stump, which is apt to occur when the attachments of the hyoid bone

to the jaw have been extensively divided. This complication may be met by securing the tissues of the stump to the tissues at the sides of the mouth by two or more silkworm-gut sutures. These sutures may be allowed to cut their way out in the course of time.

In certain cases, in order to effect a more complete removal of the cancerous parts, portions of the jaw have been excised together with the tongue. In these instances the implication of the floor of the mouth has been very decided. These operations are extensive and serious, and before a surgeon undertakes so grave a measure he should be quite convinced that the disease has not extended so far as to render a complete and satisfactory excision almost impossible.

THE CHOICE OF AN OPERATION

Many decided and yet very opposite views have been expressed upon the question as to which is the best method of excising the tongue.

Each surgeon will commend the operation of which he has personally the most experience and with which he is most familiar.

Whitehead's method is open to the serious objection that it does not deal with the all-important groups of lymphatic glands.

Syme's operation is quite needlessly severe, and needlessly complicated. The after-treatment is of long duration, and trouble often arises from the divided bone. As the attachments of the tongue to the hyoid bone are extensively divided, the stump is apt to fall back, and the control over the larynx may be so modified that the patient is less well able to prevent discharges from running into the air-passages.

The possible advantages of the method of *excision after securing the linguals* over Whitehead's method are these: In the former operation the excision can be conducted very safely and easily. There is no pool of blood on the floor of the mouth to obscure the surgeon's movements, and the excision can be carried out with great accuracy and precision. In Whitehead's operation the bleeding may be copious and sufficiently free to hamper the surgeon's movements and to complicate the operation. To an inexperienced operator the bleeding may be alarming, and may lead to hurried and incoherent

action. The fact that the hæmorrhage is readily controlled does not render it the less troublesome or a less serious complication during the actual excision.

The advantages of the method by securing the linguals are not limited to the one feature of rendering the operation almost bloodless, and relieving the surgeon of all anxiety as to hæmorrhage.

Whether the submaxillary salivary glands are removed or not, the lymphatic glands can be dealt with, and the results of the method are greatly superior to the old operations limited to the tongue itself. It is true that with the greatest care and the most elaborate operation the surgeon cannot guarantee freedom from recurrence, as small epitheliomatous deposits may miss the nearest group of glands and lodge in some distant or unlikely site. We have known cases of recurrence low down in the posterior triangle, for example; and it is impossible for the surgeon to clear both triangles of the neck.

The advocates of a *double operation* contend that death from septic pneumonia is rendered thereby less likely, and that if the glands and tongue are dealt with at the same time there may be severe shock from the long operation. From a personal experience of over fifty cases we do not think there is much weight in either objection.

Excision through the side of the neck (the so-called Kocher's operation) is severe, and involves a wide opening up of the connective tissue of the neck.

This operation appears to be somewhat too extensive for the ordinary case of excision of the tongue, and many surgeons may be inclined to dispense with the preliminary tracheotomy.

The incision can be carried out easily and completely, and the hæmorrhage can be kept well under control.

The operation is well suited for cases in which the tongue is affected far back, in which diseased glands exist, or in which the floor of the mouth is involved upon one side. The resulting wound can be kept clean, but the after-treatment is tedious. In one very successful case reported by Mr. Barker (*Lancet*, Oct. 15th, 1887) it is noted that the patient continued to be fed with a tube for sixteen days after the excision.

AFTER-TREATMENT

In a case of excision of the tongue after ligature of the linguals in the neck, the following treatment is carried out.

Nothing is applied to the mouth at the time of the operation. The slight oozing, and the salivation which continues for some hours after the excision, render an application of little avail.

The patient is encouraged to sit up in bed as soon as possible. Morphia should be avoided whenever it can be: it dulls the reflex sensibility of the patient, and may cause him to allow fluid to run down into the air-passages.

He must be impressed with the importance of allowing all discharge to escape from the mouth, and of swallowing none of it.

The mouth must be kept constantly washed out. This rinsing of the mouth cannot be too frequently performed. Every half-hour in the day, and three or four times in the night, are not too often. The best wash is carbolic lotion (1 in 60 to 1 in 80); others are referred to on page 257.

During the first twenty-four hours the patient may be fed *per rectum*, and ice only should be taken by the mouth. The use of ice should be very moderate, as it does little but fill the mouth with fluid, which gives the patient some trouble to get rid of. At the end of twenty-four hours the patient should swallow food. It is best given with an ordinary feeder, while the man sits upright, with his head inclined to one side. To the feeder is attached a few inches of soft rubber tube.

The difficulty of swallowing is usually got over with a little patience and practice. Should the patient be quite unable to swallow, then he must be fed with a nasal or œsophageal tube.

One feature in the after-treatment of these cases must not be lost sight of. *The patient must be well fed.* As soon as enough nourishment is taken *per os*, the nutrient enemata may be discontinued. After every occasion upon which food is taken, the mouth must be well washed out.

Now and then the cavity may be flushed out with an irrigator. These operation cases demand the undivided attention of two nurses, one for day duty and one for night, for upon

the careful nursing of the case as much depends as upon the operation itself.

No drainage of the mouth cavity is needed in these cases. If the part becomes unduly offensive, a stronger solution of carbolic acid must be used, and the mere rinsing out of the mouth must be replaced by a flushing out of the cavity with the irrigator.

These perpetual washings-out of the mouth involve considerable annoyance to the patient, but they are necessary only for a few days, and it must be borne in mind that the usual cause of death after these operations is septic pneumonia.

The wounds in the neck are treated in the usual way. They almost invariably heal up by first intention.

The patient may be allowed up on the third or fourth day, and in the majority of the cases we have treated at the London Hospital the patient has left the hospital between the seventh and the tenth day after the excision.

We have been very much disappointed with a solution of permanganate of potash as a wash, and have long since given it up. Boracic lotion is still more ineffective. Thymoglycine, one part to four or five of water, is a good mouth-wash.

Some surgeons, notably Woelfler, have advised that the floor of the mouth be packed with iodoform gauze. We have tried this dressing, and have found it unsatisfactory and dangerous.

Mr. Whitehead employs the varnish with which his name is associated (page 250). He does not encourage his patients to consider themselves invalids. They get up on the day after the operation, and may on that day take open-air exercise. Food is administered by the mouth on the day after the excision. In the matter of rapidity of recovery, Mr. Whitehead's cases stand pre-eminent.

Kocher and many others advise that the patient be fed with a tube, to prevent any of the nutriment prescribed from lodging in the mouth and decomposing there. We venture to think that the tube should only be employed in those few cases in which the patient appears to be really unable to swallow. Even in such instances the sooner it is abandoned the better.

The wholesale cauterisation of the wound immediately after the operation with pure carbolic acid, a strong solution of chloride

of zinc, or powdered permanganate of potash, cannot be other than condemned. It is purposeless, and attended with intense pain.

The after-treatment of these cases involves three great factors :—

1st. Let the patient be well fed.

2nd. Let all discharges escape from the mouth.

3rd. Keep the cavity of the mouth clean and sweet.

After-Results.—It is estimated that the duration of life in cases of cancer of the tongue, when no treatment is carried out, is twelve to eighteen months.

It has been clearly shown that, even when recurrence occurs after excision, the patient's life has been prolonged, his more distressing symptoms relieved, and his comfort greatly added to.

Taking excision of the tongue generally, the mortality of the operation is now below 10 per cent.

Not many years ago the mortality was 30 per cent., and between the years 1860 and 1880 Billroth gives the mortality as 22 per cent.

Those interested in statistics as to "cure" by operation on cancer of the tongue will find various lists in the writings of Mr. Butlin, Mr. Whitehead, and many other places. We do not think it is worth while contrasting individual statistics, for one surgeon will carefully select his cases, another will operate on almost desperate ones. Everything turns on early diagnosis and free excision, together with removal of glands at the same time. There is unfortunately no time-limit as to freedom from recurrence, and it is still true that the majority of patients with cancer of the tongue ultimately succumb, perhaps after several years' reprieve by operation, from some form of cancer. It may be noted that whilst a few most successful results have been obtained by operation limited to the mouth, the prognosis has been on the whole much improved by the more radical methods, such as have been described on page 244.

CHAPTER XI

REMOVAL OF TUMOURS OF THE TONSIL

THE growths concerned in these operations are usually either epitheliomata or round-celled sarcomata.

The malignancy of these tumours, their rapid growth, the early implication of the lymphatic glands, and the deep position of the tonsil, have rendered all attempts to remove them unsatisfactory.

Nevertheless, although recurrence of the growth is the rule, its excision, together with that of all the lymphatic glands which drain from it, should be carried out in all cases in which even a few months' respite may reasonably be anticipated. In almost every case which comes under the surgeon there are already secondary deposits in the lymphatic glands, especially those situated at the angle of the jaw and lying deeply over the bifurcation of the carotid artery. The excision of these glands should form the first stage of the operation, and at the same time the external carotid artery should as a rule be ligatured. The tonsil itself is very vascular, receiving blood from the tonsillar and palatine branches of the facial artery, from the descending palatine branch of the internal maxillary, from the dorsalis linguæ of the lingual, and from the ascending pharyngeal.

The arteries named are branches of the external carotid, and a preliminary ligature of the latter will prevent hæmorrhage from all of them, except the ascending pharyngeal, the origin of which will probably be below the ligature. It may be tied separately.

This preliminary ligature of the external carotid may render an extensive operation on the tonsil region almost bloodless. It is free from the risk attending occlusion of the common carotid (especially in elderly subjects), and is strongly to be recommended.

The tonsil is in relation externally with the superior constrictor, and corresponds, as regards the surface, to the angle of the lower jaw.

The internal carotid is about four-fifths of an inch to the outer and posterior aspect of the tonsil, but may be brought near to it when the vessel is tortuous. The facial artery, also when tortuous, may be brought close to the front border of the tonsil. Of important cervical structures, the nearest to the tonsil is the glosso-pharyngeal nerve. The ascending pharyngeal artery is also in near relation with it.

A tumour of the tonsil may be removed through the mouth or through the neck (pharyngotomy).

By either method preliminary tracheotomy may be dispensed with, though the instruments for it should be at hand.

1. OPERATION THROUGH THE MOUTH

A loop of ligature should be passed through the middle line of the tongue, so that traction can be made on the latter when desired.

The patient's head being turned towards the opposite side, the usual incision (somewhat prolonged) should be made for ligature of the external carotid, this vessel being secured as near to its origin as possible. Through this incision all lymphatic glands felt to be enlarged, together with any others that can be discovered, are carefully dissected out. The wound is then sewn up.

The patient's head and shoulders must now be well raised, and the best possible light obtained.

A Mason's gag is introduced upon the side opposite to the affected tonsil, and the mouth is as widely opened as is possible. The excision should be effected by long straight scissors, similar to those used for Whitehead's operation on the tongue. The growth may be fixed by long slender forceps of the dissecting-room pattern (but with toothed points), or by a tenaculum.

If it appears that sufficient room cannot be obtained through the mouth, the cheek must be slit up as far as is necessary. In effecting this division the facial artery will be severed.

The operator now proceeds to carry out the excision. In the case of a sarcoma, the growth (when the mucous membrane

has been divided over it) may sometimes be shelled out with comparative ease, the surgeon using his forefinger, and supplementing its action with a broad periosteal elevator.

When the growth cannot be dealt with in this way, it must be removed by cutting with the scissors.

In carrying out the excision the operator may encroach upon the palate or approach the tongue.

The mass should be drawn well into the mouth, and its excision should be effected deliberately and precisely, and without undue haste.

Bleeding may be checked by sponge pressure or by pressure forceps, or by torsion.

The use of the écraseur in such cases is to be condemned, and an attempt to remove the mass with the galvanic cautery or with Paquelin's cautery is needlessly dangerous. By using the cautery in this deep cavity, it is probable that the growth would be but imperfectly removed, while great risk would be incurred of producing eschars on the walls of adjacent blood-vessels, and of establishing conditions favourable to secondary hæmorrhage and to septic processes.

2. OPERATION THROUGH THE NECK (PHARYNGOTOMY)

A. **Cheever's Method.**—An incision some three or four inches in length is made along the anterior border of the sterno-mastoid muscle from the level of the lobule of the ear to below the level of the tumour. A second incision is made at an angle to the first along the body of the lower jaw.

The flaps of skin bounded by these incisions are drawn aside, and a dissection is carried down to the tumour.

In dividing the superficial structures, the commencement of the external jugular vein will probably be severed. The fascia must be well opened up. The lower branches of the facial nerve will be encountered. The stylo-hyoid, stylo-glossus, stylo-pharyngeus, and probably the digastric muscles, will need to be divided.

The facial artery and vein cross the area of the wound, and must be ligatured and divided.

The submaxillary gland is drawn forwards, the parotid upwards.

The internal jugular vein and internal carotid artery will be exposed, and must be drawn outwards with retractors.

The dissection terminates at the pharyngeal wall.

The tumour is now reached, and is removed with the scalpel or scissors, together with the portion of the pharyngeal wall to which it is attached.

The use of the actual cautery in these cases is to be condemned.

Any enlarged gland met with during the dissection may be removed. The skin-wound is closed and a drain inserted.

In the place of the incision along the ramus of the jaw, Mr. Golding Bird slit up the cheek, and was in that way enabled to approach the growth from both sides (*Clin. Soc. Trans.*, vol. xvi. page 9).

B. **Czerny's Method.**—A tracheotomy is performed, and the air-passage occluded by Trendelenburg's tampon-cannula, or by some other means. (*See* page 198.)

An incision is inclined downwards and outwards from the angle of the mouth to the anterior border of the masseter, and thence to the level of the hyoid bone.

The lower jaw is exposed, and is divided just in front of the last molar, the saw-cut following the same inclination as the skin incision. The two portions of bone are held well aside. The following muscles will need to be divided, viz. buccinator, digastric, stylo-glossus, stylo-hyoid, stylo-pharyngeus. The following vessels will need to be secured, viz. the facial artery and vein, and probably the lingual and its vein. Care must be taken of the salivary glands, and of the lingual, hypo-glossal, and glosso-pharyngeal nerves.

The tumour is removed with the scalpel or scissors. The two fragments of the jaw are adjusted by silver sutures. The skin wound is closed, and also the wound in the mucous membrane of the cheek (as far as is possible).

A drainage-tube should be employed.

Better access to the tonsil will be obtained if the incision is made to start not from the angle of the mouth, but from the tip of the mastoid process. From the angle of the jaw a small incision downwards may be added in order to remove the lymphatic glands, or upwards to facilitate division of the jaw. The

latter should be drilled through for passage of the silver wire before the saw is used, as it is otherwise awkward to use the drill. The line of section of the bone should pass obliquely downwards, forwards, and outwards, so that the fragments shall present a bevelled edge to favour their subsequent union.

Comment.—These operations on the tonsil have, up to the present time, proved very unsatisfactory. There are the difficulties—first of treating the cases early enough; and, secondly, of effecting a complete removal.

The intra-oral method should be attempted when the growth is quite small and easily defined. In all other instances, especially where there is any glandular implication, the pharynx should be opened from the neck. If there be extensive gland disease, any operation will probably be quite unjustifiable.

Mr. Butlin gives the following as the results of twenty-three operations for the removal of malignant tumours of the tonsil: Three died from the operation; three were lost sight of; ten perished from rapid recurrence, and four from somewhat later recurrence; three only were alive at periods respectively of four, twelve, and twenty-four months after the operation.

Less gloomy results are recorded by Sir W. Watson Cheyne, who discusses the subject fully in his work on "The Operative Treatment of Malignant Diseases," 1900.

The **after-treatment** of these cases resembles that carried out in the more extensive operations for the excision of the tongue (e.g. Kocher's operation, page 257).

The mouth must be kept scrupulously clean, every facility must be afforded for free drainage, the wound must be frequently irrigated, and when the neck has been opened the patient should be fed through a tube for some days after the operation.

The head should be fixed after the manner adopted in treating cases of cut throat.

CHAPTER XII

OPERATIONS ON THE ŒSOPHAGUS

ŒSOPHAGOTOMY

Anatomical Points.—The gullet commences opposite the cricoid cartilage, and on a level with the sixth cervical vertebra.

The average diameter of its lumen is 20 mm. (the diameter of a sixpenny piece); at the cricoid cartilage it is only 14 mm. The œsophagus in the neck follows the curve of the cervical spine, and also curves a little laterally (to the left), the sweep of the curve extending from the cricoid to the root of the neck. It is in close relation in the neck with the trachea, the thyroid body, the carotid arteries (especially the left), the inferior thyroid artery, the middle thyroid veins, and the recurrent laryngeal nerves.

The operation of œsophagotomy is carried out, as a rule, for the removal of foreign bodies which have become impacted in the tube. In one or two instances attempts have been made to dilate a simple stricture of the gullet through an incision in the neck.

Instruments required.—Gag; tongue forceps; œsophageal bougie and forceps; scalpels; blunt-pointed bistoury; retractors; sharp hook; artery and pressure forceps; dissecting forceps; long-bladed, toothed dissecting forceps; scissors; needles; needle-holder; periosteal elevator to assist in removing the foreign body.

The Operation.—The general features of the operation are similar to those which attend a ligature of the common carotid. (*See* page 376.) The gullet is approached from the *left* side of the neck, inasmuch as the tube inclines to that side. Should the foreign body be felt more distinctly upon the right side, then the incision may be made in that quarter.

The shoulders are well raised, the head is a little extended and is turned to the right or opposite side.

Every attempt should have been made to define the exact position of the foreign body before the incision is begun. A skiagram of the neck showing the foreign body is indispensable. The situation of the cut will be influenced by the locality of the foreign body. Very usually it is the commencement of the œsophagus that is exposed.

The skin incision will commence opposite to the upper border of the thyroid cartilage, and will be continued downwards along the anterior border of the sterno-mastoid muscle for about three inches.*

The first steps of the operation are identical with those for ligaturing the common carotid. (*See* page 379.)

As soon as the skin and fascia have been divided, the finger should be introduced into the wound, and the position of the impacted substance be further defined.

The omo-hyoid muscle is drawn downwards, and must be divided if necessary. The sterno-hyoid and sterno-thyroid muscles must be drawn a little aside, and, in cases where the foreign body is low down, may need to undergo some division of their fibres.

The sterno-mastoid and the large vessels are drawn outwards. The carotid sheath is not disturbed.

The trachea and larynx are drawn over, or rather tilted over, to the inner or opposite side.

The position of the gullet can now be readily made out.

It may be desirable at this stage to pass a bougie or a pair of œsophageal forceps, in order accurately to demonstrate the situation of the tube and of the impacted body. It must be remembered that the œsophagus, when empty, is flat and tape-like, and does not exist as the well-rounded tube which figures in most anatomical text-books.

The inferior thyroid artery and the superior and middle

* Hans (*Zentrabl. f. Chir.*, No. 34, 1906) advocates a long median incision over the trachea. The deep dissection does not materially differ from that described above. Hans suggests that with the aid of exposure of the œsophagus through this incision it may sometimes be possible to remove the foreign body through the mouth without incising the tube.

thyroid veins must be carefully avoided. The last-named vessels will usually need to be ligatured and divided.

All bleeding having been arrested, the gullet is steadied by a pair of fine, long-bladed, toothed forceps, and is opened longitudinally over the site of the foreign body.

The recurrent laryngeal nerve runs in the groove between the œsophagus and the trachea. The gullet must be opened through its lateral wall, so as to avoid injury to this nerve. In the actual operation it will appear that the œsophagus is being opened as far back as possible.

The opening in the tube must not be extended by tearing, or be dilated with dressing-forceps; it must be cautiously enlarged by a blunt-pointed bistoury.

The removal of the foreign body must be carried out with the greatest care, and a curved periosteal elevator will be found a most valuable instrument in freeing the substance and prising it into the wound.

When the body is of irregular shape, and has been long impacted, very great difficulty may be experienced in removing it. I (F. T.) was occupied in one case for more than twenty minutes in extracting from the gullet a hard-metal plate of teeth, which had been impacted for eleven months.

By the introduction of forceps through the wound, foreign bodies have been extracted from the thoracic segment of the œsophagus.

If the wound in the gullet be a clean cut, if the case be recent, and the foreign body have been impacted for but a short space of time, then the œsophageal incision should be closed; and this more especially applies to the cases of children and young subjects. The sutures employed should be of very fine catgut, and they can be most conveniently introduced by means of a curved needle, held in a suitable holder.

If, however, the body has been long impacted and the gullet is much ulcerated, or if the wound in the gullet has been lacerated, and has been exposed to much bruising, then the use of deep sutures had better be dispensed with. The skin-wound in each case may be narrowed above and below by a few suture points, but the median and main part of the wound must be left open. A good-sized drainage-tube should be passed to the bottom

of the wound. In no case is it well to close the superficial wound entirely, even in instances where the incision in the œsophagus has been united. The wound in the gullet may yield, or may be torn open by violent vomiting, and the food-matters and mucus which find their way into the tissues of the neck should be permitted the very freest means of escape.

If, in a case where the gullet wound has been closed, no sign of extravasation occur for seven days or so after the operation, then the superficial wound may safely be closed.

An open wound is the great safeguard after œsophagotomy.

Even when the wound has been long open, and when food and mucus have escaped from the neck, and when much unhealthy suppuration has been induced, the parts at the end close well, and the resulting cicatrix is often wonderfully neat.

After-Treatment.—The after-treatment of these cases involves considerable care, and often not a few difficulties.

The patient should lie in bed, with the head and shoulders well raised.

The neck must be fixed and made rigid, and this can be effected by means of one of the simpler forms of apparatus employed in cases of cervical caries. It is essential that the part be kept at rest, and unless the head be fixed it will be found that the region of the wound is very frequently disturbed, especially when the patient is fed.

The longer the patient can be kept, immediately after the operation, without food *per os*, the better. The strength must be maintained by nutrient enemata. Thirst may be relieved by rectal injections of warm water.

The patient may be fed by a tube on the second or third day. The tube should be soft, and should be passed by the mouth. This method of feeding must be repeated until the parts are sound.

If the wound in the gullet has been closed, and has remained closed, the tube may be given up in seven or ten days. If the wound be left open, or if it reopen after it has been closed, the tube should be employed until the wound in the neck is granulating well and has been reduced to small dimensions, and until it is evident that the cut in the gullet has healed.

When the aperture in the œsophagus remains free there

is a great disposition for the cervical wound to become very foul, in spite of ordinary attention. The mouth should be frequently rinsed out with a carbolic solution, and the wound, which should be dressed very lightly with gauze, should be irrigated with some antiseptic solution many times a day. When the patient is fed with the tube a little food is very apt to escape into the mouth, and also out of the wound. Both mouth and wound should, therefore, be well washed out after each act of feeding.

Iodoform Boric powder is a very suitable material for dusting upon the wound.

The chief cause of death in these cases is septicæmia, consequent upon the foul condition of the wound. Other elements in the mortality are cellulitis, pneumonia, and exhaustion.

ŒSOPHAGOSTOMY AND ŒSOPHAGECTOMY

The former of these operations has been proposed as a substitute for gastrostomy in cases of cancer of the gullet. It is assumed that the stricture is high up, that the tube can be opened below it, and that the patient can be fed through the artificial opening thus established. The objections to this operation are, however, so numerous and so pertinent that it has not been adopted, and it cannot be considered to belong to the domain of practical surgery.

Œsophagectomy, or excision of portions of the gullet (for malignant disease), was first suggested by Billroth, and first carried out successfully by Czerny in 1877. Czerny's patient died of recurrence of the disease about a year after the operation. An account of the procedure is to be found in *Beitr. zur operativen Chir.*, p. 48, 1878. Since then a good many surgeons have performed this operation, but the immediate mortality has been heavy, the ultimate results very poor. Union between the divided ends of the œsophagus is rarely if ever satisfactory, and it is doubtful if the operation is ever justifiable. There is some hope that the treatment of these cancers with radium may prove successful. Something may be done to relieve the patient by the use of Symonds's œsophageal tubes or the passage from time to time of a flexible bougie, though the danger of this last measure is well known.

CHAPTER XIII

EXCISION OF THE UPPER JAW

This operation is considered to refer usually to the removal of the superior maxillary bone of one side, but to include also the rarer operation in which both bones—and therefore the whole of the upper jaw—are excised at one sitting.

The operation has been performed for the relief of several conditions, but is at the present day almost limited to the treatment of malignant growths (epithelioma and sarcoma) which involve the upper maxilla.

The operations for the removal of innocent tumours are for the most part partial, and, indeed, the conditions must be very exceptional in which the excision of the entire bone on one side would be called for in dealing with an innocent growth.

Thus, in removing a myeloid epulis the portion of bone from which it grows should be gouged or chiselled away to prevent recurrence. In dealing with a dentigerous cyst of either jaw the thin expanded outer wall is freely cut away, the misplaced tooth which is the cause of the cyst can then be removed. It is worth while to emphasise the fact that, owing to a mistaken diagnosis, unnecessary removal of a large portion of the jaw has been sometimes performed for a dentigerous cyst or a simple hypertrophy of bone. A doubtful tumour of the jaws, especially in young subjects, should always be cut into, and a microscopic section examined, before resorting to a graver operation.

The value of the usual operation—viz. the removal of one superior maxilla for malignant disease—is a matter of question. For epithelioma commencing at the alveolar border, or for burrowing endothelioma in the substance of the jaw, a free excision may give a satisfactory result. But in the cases of soft cancer or sarcoma involving the whole antrum of Highmore and invading the cheek, nose or orbit, the prognosis of operation is deplorably bad.

The operation was originally proposed by Lizars in 1826 (" A System of Anatom. Plates," Part ix., Edin., 1826), but was first carried out (independently of Lizars' suggestion) by Gensoul in 1827 (" Lettre Chirurgicale," etc., Paris, 1833).

On many occasions previously to these dates portions of the upper jaw had been removed, or the contents of the antrum evacuated. The excision of both superior maxillary bones at one sitting appears to have been first accomplished by Heyfelder in 1844.

Anatomical Points.—The details of the anatomy of the superior maxillary bone must be borne in mind, as well as its relations to surrounding parts. The bone forms the largest part of the face, of the outer wall of the nose, of the roof of the mouth, and of the floor of the orbit. The bone as a whole is thin and shell-like, its most substantial part being the malar process. It articulates with nine bones, and no fewer than nine muscles are attached to it.

The bony connections to be dealt with in the operation are the following: (1) the connection with the malar bone at the outer side of the orbit; (2) the connection of the nasal process with the frontal, nasal, and lachrymal bones; (3) the connections of the orbital plate with the ethmoid and palate; (4) the connection with the opposite bone, and with the palate in the roof of the mouth; and (5) the connection behind with the palate bone and the fibrous attachments to the pterygoid processes.

In excising the bone in the living subject, the upper part of the nasal process is usually left behind, the malar bone is divided, and a portion of it removed with the maxilla. The inferior turbinated bone is of course included in the parts excised, and also the whole or the greater part of the palate bone.

In cutting through the nasal process the lachrymal sac will be damaged and the nasal duct cut across.

The attachments of the soft palate to the palate bone must be severed.

The blood-vessels which are concerned in the operation are certain branches of the facial artery, the infra-orbital artery, the alveolar branch of the internal maxillary, the descending palatine, pterygo-palatine, and spheno-palatine arteries, and the deep facial vein.

All these vessels are, under normal conditions, small.

Instruments required.—Gag; tracheotomy tube; scalpels; tooth forceps; bone-cutting forceps of various patterns; sequestrum forceps; lion forceps; volsella; metacarpal saw; chisel and mallet; rugine; periosteal elevator; strong scissors, both straight and curved on the flat; Wells' forceps; Paquelin's cautery; needles, sutures, etc.; sponge-holders.

Preliminary Measures.—During the performance of the operation considerable danger may be incurred from hæmorrhage. Not only may the bleeding be copious in amount, but the blood may readily find its way into the air-passages.

Various measures have been adopted to meet this complication. Lizars in his first operation ligatured the internal maxillary and temporal arteries as a preliminary step. In his second case he secured the external carotid. With a like object in view, a ligature of the common carotid has been both advised and carried out. This procedure is, however, far too dangerous from the point of view of central anæmia, whereas ligature of the external carotid alone is free from risk. Moreover the incision made in the side of the neck for ligature of this vessel will enable the operator to remove any suspicious lymphatic glands. On the whole, though we do not consider preliminary ligature of the external carotid as essential, there is little doubt that it may facilitate the operation, and slightly increase the chance of success. Mr. F. S. Eve (*Brit. Med. Journ.*, June 29th, 1907) advocates preliminary ligature, with laryngotomy, as routine measures in this operation.

Professor Rose advises that the head be so far thrown back that the vertex is directed towards the ground, and points out that in that attitude the blood can only occupy the upper part of the pharynx, and must escape through the wound and the nose.

The position, however, is most inconvenient to the surgeon; it does not prove so efficacious as it may appear to be, and it leads to considerable venous congestion of the head and face. The complete lateral position mentioned in the description of the operation by median incision has great advantages (page 273).

Some operators make a practice of performing tracheotomy, and of then plugging the larynx with a piece of fine Turkey sponge to

which a tape is attached; or they make use of Trendelenburg's tracheal tampon-cannula (*see* page 198).

We have used Trendelenburg's cannula in many operations within the mouth, and have found it to effect its purpose. Care should be taken to test the instrument before it is employed. The thin india-rubber tissue which forms the tampon soon perishes, and should be replaced every time the instrument is used. Even if this cannula be employed, it is necessary to place a sponge over the larynx, as a considerable clot may form in the laryngeal cavity above the tampon. It may be here observed that if the cannula be retained for some time after the operation, as a precaution in the event of secondary bleeding occurring, it will probably be found to be no longer of effect in plugging the trachea. If the instrument be retained, the india-rubber tissue is very apt to become disorganised; and in the case of one cannula, which had been retained only forty-eight hours, we found the tampon on removal to be represented only by mere shreds of indiarubber.

After excision of the upper jaw, if laryngotomy has been done, it is advisable to retain the tube in place for a few days, hence the simple metal tube without rubber sheath should be employed.

In the majority of cases neither the preliminary ligature of an artery nor a preliminary tracheotomy is absolutely essential, but, as already noted, some authorities, such as Mr. F. S. Eve, hold that they render the operation easier and safer, and this opinion we fully endorse.

If, on the other hand, the posterior nares be carefully plugged before the operation, if the division of the palate be left to the last, if the later stages of the operation be rapidly executed, and if an assistant is very ready with pressure forceps and sponges, it will usually be found that the bleeding can be efficiently dealt with.

COMPLETE OPERATIONS

The many different methods described for excising this bone are distinguished from one another by little else than the disposition of the skin incision.

The following operations will be described:—

1. Operation by a median incision.
2. Velpeau's operation.

1. **The Operation by a Median Incision.**—This procedure forms, without doubt, the best measure for excising the superior maxilla.

The operation is known in most French text-books as Nélaton's or Liston's operation, and in most English books as Fergusson's operation.

The exact methods carried out by Liston and Fergusson are alluded to in a later section. The present operation would appear to have originated with Blandin ("Anat. Topograph.," 1834, page 122).

The patient lies upon the back, with the head and shoulders well raised. The face, if the patient be a male, should have been already shaved. The head is turned to the sound side.

Hewitt and Sheild (*Med.-Chir. Trans.*, 1896, page 18) advise the complete lateral position of the patient, with his head at the edge of the table and the face turned towards the floor. Blood drains away readily in this position without risk of its entering the trachea.

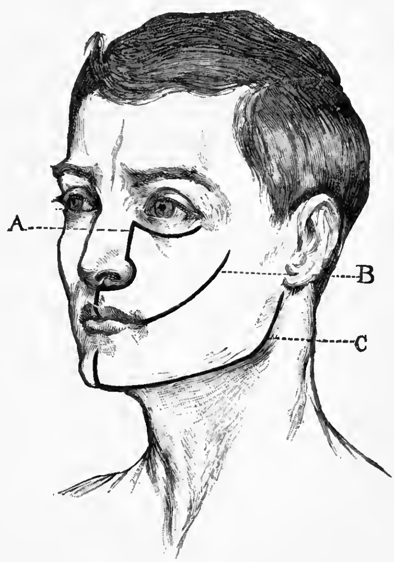

FIG. 300.—EXCISION OF THE JAWS.
A, By a median incision; B, By Velpeau's method; C, Excision of the lower jaw.

The surgeon stands on the patient's right-hand side in dealing with either side of the jaw. The chief assistant should take his place opposite to him. Another assistant may stand by the surgeon's side. The posterior nares are well plugged.

(1) The incision is commenced at a point half an inch below the inner canthus, is carried down by the side of the nose—where the nose joins the face—follows the groove which limits the ala nasi, and, skirting the nostril, reaches the median line of the lip.

While this cut is being made, an assistant may compress the facial artery.

When the lip is reached, the chief assistant grasps each extremity of the lip (at either angle of the mouth) between the finger and thumb, so as to compress the coronary arteries. The incision is then carried through the median line of the upper lip into the mouth (Fig. 300, A).

The superior coronary arteries are at once seized and secured.

While the lip is being dealt with the upper part of the wound is being compressed by a sponge.

In this stage of the operation the following vessels are divided, viz. the angular artery and the large angular vein, the lateralis nasi artery, the superior coronary, the artery to the nasal septum, and some trifling branches of the infra-orbital.

(2) A second incision is now carried along the lower margin of the orbit. At its commencement it starts from the point of the first incision, and ends over the malar bone (Fig. 300, A).

(3) The cheek flap thus marked out is rapidly raised from the bone, and should contain all the soft parts down to the maxilla.

No attempt should be made to save the periosteum. In dissecting up this flap the infra-orbital artery is divided. Care should be taken that no blood runs into the mouth, and an assistant should follow the flap with a sponge.

Throughout the operation sponge pressure is the main means of checking hæmorrhage.

(4) The operator should now separate the nasal cartilages from the bones, and should then divide the nasal process. This may be done with a fine saw or a chisel (Fig. 301, A). He should next proceed to divide the periosteum along the lower edge of the orbit. With the elevator the periosteum of the floor of the orbit is carefully raised, and in effecting this the origin of the inferior oblique muscle is separated.

With a fine chisel the orbital plate may be divided as far within the orbit as is necessary. The chisel-cut will commence at the point at which the nasal process of the maxilla has been divided, and will end at the spheno-maxillary fissure (Fig. 301). If it be considered necessary to take away the whole of the orbital plate of the maxilla, then a chisel-cut can scarcely avail, and the bone must be wrenched away from its attachments in the final act of removal.

The last step of this stage of the operation is to divide the

malar bone. This may be done with a chisel or a small saw. The malar bone is divided obliquely (from above downwards and outwards) at a point about the centre of the bone, and the saw or chisel is so applied that the section will extend into the spheno-maxillary fissure, the exact site of which should have been previously defined (Fig. 301, B).

(5) The palate part of the bone alone remains with its connections undisturbed. The mouth having been well opened, the central incisor tooth on the diseased side is removed, the muco-periosteal covering of the hard palate is divided in the median line, and a knife is drawn along the floor of the nose from before backwards, and as near as possible to the septum. By means of a transverse incision made through the mouth the soft palate is loosely separated from the hard.

FIG. 301.—SAW INCISION IN THE MAXILLÆ.

A, B, C, Excision of upper jaw; D, Boeckel's operation (nasal polypus); E, C, Guérin's operation (partial excision); F, F, Langenbeck's operation (nasal polypus); G, Excision of lower jaw; H, Removal of portion of alveolus; I, Esmarch's operation (ankylosis of jaw).

A keyhole saw is now introduced through the nose, and the bony palate divided as near to the median line as is possible (Fig. 301, C). This step of the operation should be rapidly performed, as there is often much bleeding from the palatine arteries, which are necessarily divided.

(6) The surgeon finally grasps the bone with lion forceps, holding the instrument with its blades opened vertically. One blade takes hold of the orbital plate, and the other of the alveolus.

The maxilla is then wrenched from its few remaining attachments. These will in part concern the orbital plate, and in part the attachment existing between the maxilla and the pterygoid process. The separation of the bone from the last-named process may be aided by bone-cutting forceps bent at an angle and introduced behind the maxillary tuberosity.

Care must be taken at this stage that the soft palate is freed completely from its connections with the hard.

Without bringing much force to bear upon the forceps, the bone is finally removed.

(7) Any bleeding from the depths of the cavity should now be checked so far as is possible.

It will usually be desirable to plug the cavity with gauze. Iodoform or cyanide gauze may be employed. The amount introduced must be noted, and the ends of the strips so placed that they can be readily reached from the mouth.

A silk thread may be attached to the end of each strip, and brought out of the mouth and fastened to the cheek.

The actual cautery may sometimes be used with good effect to check the hæmorrhage.

The skin wound is finally united very carefully with silkworm-gut sutures, especial care being taken accurately to adjust the red margin of the lip. No harelip pins are necessary in any ordinary case.

The wound is finally well dusted with iodoform, and dressed with a firm dry dressing.

Comment.—This operation has the following great advantages:—The bone is well exposed, and plenty of room is provided for its excision; the vessels and nerves are cut at a distance from their trunks, the salivary duct is not interfered with, and the scar is so placed as to produce but little deformity. The operation, moreover, allows of easy control of the hæmorrhage.

If the posterior nares be plugged, and if the steps of the operation be followed in the order given, no blood should find its way into the mouth until the last stages of the excision are reached. Farabeuf does not divide the lip until towards the last. His first incision ends at the ala of the nostril. The nasal, orbital, and malar parts of the bone are separated. The

cut is finally carried through the lip, and the palate segment of the bone dealt with.

In many text-books the removal of the incisor tooth is one of the first steps of the operation. This is not necessary, and blood from the socket of the tooth running into the mouth may add a needless complication to the procedure.

The excision should be carried out rapidly, but without haste, and, above all, without violence.

The connections of the bone must be well freed before any attempt is made to wrench it away.

Carefully applied pressure with fine Turkey sponge affords the best means throughout the operation of dealing with the hæmorrhage.

It is useless to make any attempt to save the muco-periosteal covering of the hard palate.

French surgeons usually employ a chain-saw to divide the malar bone. The saw is conducted into position by means of a curved needle, which is passed through the spheno-maxillary fissure.

It not infrequently happens that the bone breaks up during removal, and has then to be taken away in fragments.

After the removal of the maxilla the cavity should be examined for any traces of the growth. It is apt to spread to the pterygoid plates, which need very careful inspection.

2. **Velpeau's Operation.**—In this operation the incision is commenced at the angle of the mouth, and is carried in a curved direction through the cheek to end over the centre of the malar bone (Fig. 300, B). The incision is carried directly into the mouth, and the flap thus formed is turned inwards.

The operation is completed precisely in the manner already described.

Comment.—This incision is a modification of that originally proposed by Lizars.

Compared with the previous operation, it has these disadvantages: The bone is not so readily exposed, and there is greater difficulty in dealing with its orbital and nasal portions. The arteries of the face are divided nearer to the trunk. The parotid duct is wounded. An ugly scar results.

The measure, however, is of value in cases in which the cheek

is to a small extent invaded, and in which it is possible that the involved skin can be removed by widening the cut at the necessary spot.

The question, however, would remain as to whether any operation would be justifiable in such a case.

PARTIAL OPERATIONS

1. The alveolar part of the bone and the palate process may be readily removed through the mouth without making any incision in the skin. The upper lip is everted, and is either held up by suitable forceps or drawn up by retractors. The tissues of the cheek can, if needed, be separated to the required extent from the bone by dividing the mucous membrane along the line at which it is reflected from the cheek to the maxilla. The division of the bone is best accomplished by a chisel and mallet, the section being made horizontally. If the reflection of the soft parts be carried up to the level of the floor of the nares, the nasal cavity can be readily opened up from the mouth.

The broad rectangular retractor used in certain abdominal operations is very useful in holding up the tissues of the cheek.

2. If the whole of the maxilla be removed with the exception of the orbital plate, the median incision should be employed, with the omission of the horizontal suborbital part of the cut. The nasal process of the maxilla is divided close to its origin from the main bone. A horizontal cut is made with the chisel through the jaw between the orbital margin and the infra-orbital foramen, and the malar bone is divided obliquely close to its articulation with the maxilla.

REMOVAL OF BOTH SUPERIOR MAXILLÆ

This operation, which can but very rarely indeed be justifiable in actual practice, may be carried out by means of the median incision performed upon either side of the nose, just as in removing either the left or the right bone.

The steps of the proceeding are similar to those already described, save that the palate process is now divided with the saw.

AFTER-TREATMENT

The gauze plug employed should not be large enough to bulge out the cheek and cause a strain upon the sutures. It should be removed in twenty-four hours, as it soon becomes offensive if retained.

Every possible care should be taken that the mouth and the wound cavity are kept clean.

The patient should be raised up in bed by means of a bed-rest, so as to facilitate the escape of discharges. He should rinse out the mouth very frequently with some antiseptic solution. Carbolic acid (1 in 60 or 80) answers admirably. Two or three times a day also the cavity should be well washed out with a like solution from an irrigator provided with a wide-mouthed nozzle.

The surface wound should be kept dry, and dusted with iodoform or boric acid.

The feeding of the patient is a matter of the greatest importance. He may be fed for the first day or two with the œsophageal tube. Through this tube milk, beaten-up eggs, beef-tea, and brandy can be administered as frequently as desired.

If necessary, this mode of taking nourishment may be supplemented by nutrient enemata.

When the patient can swallow food without assistance—and he may be able to do so from the first—the mouth must be washed out each time after food is taken.

The skin wound generally heals well enough, and if no complications arise the patient may be up in a week or ten days.

When the wound is quite sound the question of fitting an artificial palate or tooth-plate has to be considered.

RESULTS

Mr. Butlin has very fully investigated the results of this operation, basing his conclusions upon the study of 108 cases. He gives the immediate mortality of the operation as 30 per cent. The causes of death—in order of frequency—are exhaustion, erysipelas or pyæmia, lung troubles, meningitis. This high mortality would be reduced when most careful antiseptic precautions are observed.

Most of the operations were performed for malignant disease, with the terrible result that only four can be claimed to have been successful—i.e. to have exhibited no return after an interval of three years.

Dr. Joseph Bryant (*Ann. of Surg.*, May, 1890) claims that the immediate mortality of the operation is only 14 per cent. He founds this statement upon a somewhat incomplete analysis of 230 cases. But probably this figure is very near the truth. Thus Mr. F. S. Eve (*Brit. Med. Journ.*, June 29th, 1907), of 12 personal cases records a mortality of 16 per cent.

The prospect of real cure from operation does not, unfortunately, grow brighter with the lessened immediate mortality.

CHAPTER XIV

OPERATIONS ON THE UPPER JAW FOR NASO-PHARYNGEAL POLYPUS, ETC.

THE naso-pharyngeal polyp, with which these operations are concerned, is that fibrous or sarcomatous growth which, taking origin from the roof of the pharynx or nasal cavity, is apt to grow almost without limit, to fill the naso-pharyngeal space, to displace and thin the facial bones, and to give rise to considerable hæmorrhage. Some may be dealt with by means of the wire écraseur passed through the nose. But in other cases a more elaborate operation will be called for.

The difficulty is not in dealing with the base or pedicle of the tumour, but in exposing it. If the root or point of origin of the polyp can be reached, the main problem in the matter of treatment will be solved.

Some of the operations consist in removing portions of the superior maxilla. In not a few instances the whole of the bone upon one side has been sacrificed in order to expose the pedicle of the tumour. Other measures consist in partially separating some portion of the bone, and in replacing it after the growth has been dealt with. These operations are generally included under the terms osteo-plastic resection, temporary resection, "luxation temporaire."

In former editions various methods were described under the names of Langenbeck, Boeckel and others (for the saw-incisions, *see* Fig. 301).

These operations are attended with considerable danger in the severer class of case. The main trouble is from hæmorrhage, which may be desperate. In cases in which much bleeding is anticipated, and in which the growth is large and prominent towards the pharynx, it is the usual practice to perform laryngotomy or tracheotomy, and to plug the opening of the larynx, or to use a Trendelenburg tampon. (*See* page 198.)

Not a few patients have died of meningitis. Others have succumbed to septicæmia, or have died apparently of mere exhaustion. A recurrence of the growth has been common.

For the reasons given above, and on account of the extreme rarity with which such operations can be indicated, we limit the description to the safer and more simple methods by the palatine route, adding a note on Rouge's nasal operation, which is ingenious and has done good service. With regard to naso-pharyngeal tumour, it is our impression that if it cannot be dealt with from the palatine aspect it is best left alone.

Median Division of the Soft Palate.—This method is the simplest, and, where it is practicable, gives excellent results. The mouth being kept open by a gag, the whole of the soft palate is divided in the middle line, and the two halves are held apart by means of suture retractors. A long curved rugine is then guided by the finger to the attachment of the tumour, and the latter is prised off from the base of the skull. The bleeding is considerable at first, but soon stops with sponge pressure. The palate is then carefully sutured with silkworm gut, and perfect union may be expected, no deformity of any kind remaining.

Nélaton's Operation.—The mouth having been widely opened by means of a Mason's gag, a median incision is made along the soft palate and uvula so as to bisect them completely. This incision is carried forwards upon the hard palate until it reaches a point half-way to the alveolus. At the termination of this median cut two transverse incisions are made which incline a little backwards (Fig. 302).

The two flaps of muco-periosteum thus marked out upon the hard palate are now dissected up with the rugine. The soft palate is detached from the hard, and the exposed portion of the latter is then removed with the chisel and mallet in the form of a quadrilateral piece of bone. The nasal mucous membrane is divided, and as much of the vomer removed as is necessary. An entrance into the naso-pharyngeal region is thus effected. After the polyp has been dealt with, the cleft in the palate is closed by staphylorraphy. (*See Bull. de la Soc. de Chir.*, tome i., page 159.)

Annandale's Operation.—Professor Annandale has demonstrated (*Lancet*, January 26, 1889) that when the alveolar margin

and palatal portions of the upper jaw have been divided along their centre from before backwards, and the bony septum of the nose cut through (the anterior nares having first been exposed by Rouge's plan), the two portions of the upper jaw can be separated to the extent of from half an inch to one inch, so as to give access to the posterior nares and base of the skull. Professor Annandale reports three examples of the operation. In one a preliminary tracheotomy was found necessary. All three patients recovered.

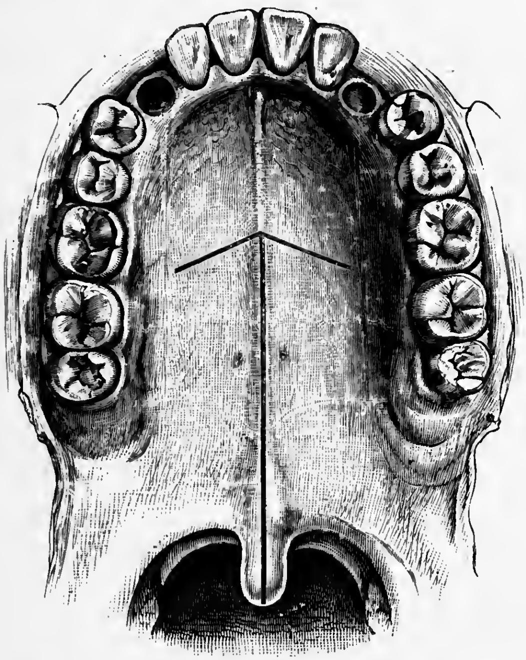

FIG. 302.—NÉLATON'S OPERATION FOR NASAL POLYPUS.

The following are the steps of the operation :—

1. The anterior nares are exposed by freely dividing the mucous membrane connecting the upper lip with the superior maxilla, and turning the lip upwards according to the plan of Rouge (page 284).

2. The bony septum of the nose is divided along its attachment to the maxilla with cutting forceps.

3. A gag having been introduced, an incision is made through the muco-periosteal covering of the hard palate in the median line. A keyhole saw is then introduced through the nose, and the alveolar margin of the upper jaw and the entire hard palate are sawn through

in the same line. It may be necessary to extract an incisor to effect this. The soft palate may or may not require division. This will depend upon the size and attachments of the growth. In two of the reported cases it was divided; in one it was not.

4. The right and left halves of the maxilla are now forcibly separated, and by means of the finger or a periosteal elevator the secondary connections of the growth are freed.

5. Through the gap the polyp is now removed. For this purpose Annandale used strong forceps, assisted by a periosteal elevator and a sharp spoon.

6. When the tumour has been removed, a plug of sterilised gauze, well dusted with iodoform, is introduced into the cavity left by the removal of the polyp.

7. The two portions of the upper jaw are brought together again, and secured by one wire suture through the alveolar margin of the bone. The cleft in the soft palate is closed by two or more horsehair sutures.

Comment.—This operation affords probably the most satisfactory method of reaching a naso-pharyngeal polyp from the palate. It does not involve a great disturbance of the parts, there is no loss of bone, and no deformity is produced. As the section is made in the median line, there is less bleeding. Should it become evident that a more extensive operation will have to be carried out, this procedure may be converted into the first step of an operation for the removal of the whole or a part of the maxilla. There are the objections that the surgeon has to operate in a confined space, and that the opening into the naso-pharynx is at a considerable distance from the usual site of the attachment of the tumour.

Rouge's Operation.—This procedure affords a means of gaining a free access to the nasal cavities without making a scar upon the face.

The operation would scarcely be carried out in dealing with naso-pharyngeal polypi, except in cases in which the growth was very small and easily reached from the front. It is, however, of admirable service in dealing with cases of obstinate ozæna, in affording a means of fully examining the nasal cavities, in removing carious bone, in dealing with lupus of the nasal mucous membrane, and in treating the more troublesome forms of nasal polypus.

The operation was described by Dr. Rouge in 1873 ("Nouvelle

Méthode pour le Traitement Chirurgical de l'Ozène.'' Lausanne, 1873).

Precautions having been taken to prevent the flow of blood into the pharynx and larynx, the upper lip is forcibly raised by an assistant, who, leaning over the patient's head, draws up the lip by taking hold of it at the angles of the mouth.

The surgeon, with scissors curved on the flat, frees it from the maxilla by cutting the mucous membrane along its line of reflection, from opposite the bicuspids of one side to a corresponding point on the other. The scissors must be kept close to the bone. The cartilaginous septum is next detached from the anterior nasal spine, and the alar cartilages are separated from their connections with the maxilla. The adjacent parts of the cheek must be separated as far as is necessary, in order that the upper lip, together with the nose, may be turned upwards towards the forehead and the anterior nares well exposed for examination.

After the operation the parts are merely replaced. No sutures are needed. The nose may be carefully and accurately supported by means of cotton-wool and a bandage, and the mouth should be kept clean by some antiseptic wash.

CHAPTER XV

EXCISION OF THE LOWER JAW

THE circumstances under which this operation is carried out are nearly identical with those which justify like excisions of the upper jaw (page 269).

A large number of the operations are partial, and only in a few instances is it necessary to remove the entire bone—i.e. both the right and left portions of the maxilla.

Anatomical Points.—The general features of the bone and of the muscles attached to it need not here be considered. The maxilla is composed of very dense hard bone, which is somewhat difficult to saw or to cut with bone forceps. The bone is weakest at the situation of the bicuspid teeth, and strongest at the symphysis. Of the sockets for the teeth, those for the incisors are the smallest, that for the canine is the widest and the deepest.

It must be remembered that with the loss of the teeth by age the alveolar part of the bone becomes absorbed.

The parotid gland is in close relation with the temporo-maxillary joint and the vertical ramus of the jaw.

The course of Stenson's duct across the masseter is represented by a line drawn from the lower margin of the concha to a point midway between the ala of the nose and the red margin of the lip. It lies about a finger's-breadth below the zygoma, having the transverse facial artery above it and the facial nerve below it. The facial nerve is represented by a line drawn across the parotid gland, in a direction forwards and a little downwards, from the spot where the anterior border of the mastoid process meets the ear.

The facial artery crosses the lower border of the jaw at the anterior margin of the masseter muscle.

The vessels divided in excising the lower jaw are the facial,

inferior coronary and labial (if the lip be severed), mental, masseteric, inferior dental, and mylo-hyoid.

The parts in danger of being damaged are the facial nerve, the internal maxillary artery, temporo-maxillary vein, auriculo-temporal nerve, external carotid artery, gustatory nerve, and the parotid, submaxillary, and sublingual glands.

Instruments required.—The same as for excision of the upper jaw, with the addition of a small saw with a movable back, or a small Butcher's saw, and a needle in a handle for securing the tongue if necessary.

REMOVAL OF ONE HALF OF THE LOWER JAW

Operation.—The patient lies upon the back, with the head and shoulders raised, and with the trunk close to the edge of the table. The surgeon stands on the side to be operated upon. Some find it more convenient to stand on the patient's right in dealing with either side of the maxilla.

The head is turned to the sound side. The chief assistant takes his place opposite to the surgeon. A second helper stands by the operator's side.

In male subjects the chin will have been already shaved.

1. A vertical incision is made through the tissues of the chin, in the middle line, starting just below the lip, which is not divided. From the lower end of this another incision is carried along and just below the inferior border of the jaw for its entire length, and is then directed upwards along the posterior margin of the ascending ramus, to end opposite to the lobule of the ear (Fig. 300, C).

The incision is carried throughout down to the bone, except in one place, viz. where the knife crosses the facial artery. Here the wound is only skin deep.

After the incision has been made, the surgeon returns to the spot indicated, exposes the facial artery by dissection, secures it between two ligatures, and divides it.

With a periosteal elevator or rugine the muscles attached to the external surface of the maxilla are rapidly separated from the bone, and are turned up with the integuments in the form of a flap. The separation is commenced at the symphysis, and carried backwards. The buccinator and masseter are

peeled off from the bone in this part of the operation. The mental and masseteric arteries, together with some smaller branches, are divided at this stage.

It is desirable that the operator should keep close to the bone.

The cavity of the mouth is now opened by dividing the buccal mucous membrane at its junction with the alveolus.

2. The surgeon now extracts one of the incisor teeth—the lateral incisor, as a rule—and with a keyhole saw divides the jaw vertically in the line of the gap (Fig. 301, G). It is often more convenient to saw the bone nearly through, and then to complete the section with suitable bone-cutting forceps. More or less of the genio-hyoid, genio-hyo-glossus, and digastric muscles will be disturbed in clearing the inner surface of the bone.

3. The anterior extremity of the divided maxilla is now drawn outwards, and with a blunt-pointed knife kept close to the bone the surgeon divides the attachment of the mylo-hyoid muscle. The internal pterygoid muscle is reached, and may be conveniently separated from the bone by means of a periosteal elevator. The lower border of the maxilla is twisted outwards, in order that the whole of the attachment of the internal pterygoid muscle may be dealt with.

The inferior dental artery and nerve are exposed and divided. In this part of the operation care must be taken to avoid injury to the sublingual and submaxillary glands.

4. The anterior part of the jaw is now forcibly depressed, in order to bring the coronoid process into view in the posterior part of the wound.

The tendon of the temporal muscle is divided with scissors curved on the flat as each part of the fibres of insertion is successively reached.

Some surgeons divide the coronoid process with a chisel and mallet, and subsequently dissect out the fragment of bone thus isolated.

The jaw is still further depressed, in order that the condyle may be brought into view.

The external pterygoid muscle is reached, and is detached with the elevator or divided with scissors. The capsule of the joint is severed, the articulation is opened and the condyle freed. Throughout this stage of the excision the jaw should be merely

depressed. It should not be twisted. If it be much everted or rotated out, the internal maxillary artery may be brought into contact with the neck of the bone, and may be accidentally divided or even torn.

It only remains now to cut the bone free of its few surviving attachments, which are represented by the internal lateral, stylo-maxillary, and pterygo-maxillary ligaments, together with more or less fascia and the remaining fibres of the outer pterygoid muscle.

All bleeding having been checked, the wound is united with silkworm-gut sutures. The chin part of the incision should be adjusted with especial care. A drainage-tube may be introduced into the hinder part of the wound, and retained there for twenty-four hours.

A dressing composed of a sponge dusted with iodoform, and kept in place by a layer of wool and a supporting bandage, will be found to be efficient.

Comment.—This operation admits of very little variation. The whole of one side of the maxilla has been removed with success through the mouth. Upon no reasonable grounds, however, can this method be recommended. It is true that no skin wound is made, but on the other hand the scar resulting from the usual wound is not disfiguring, nor is it even conspicuous. In attempting to remove the maxilla from the mouth the surgeon must find his movements hampered. Considerable damage must be inflicted upon the soft parts; there is great risk of injuring the internal maxillary artery, and efficient drainage is not provided.

If the operation be carried out as advised, there can be little need of adopting such special measures for meeting hæmorrhage as the ligature of the external carotid artery, or the plugging of the larynx after tracheotomy. It is only when dealing with large and vascular growths that any such precautions are suggested.

Some surgeons carry the skin incision entirely through the lip. This procedure, although it renders the clearing of the bone more easy, is not necessary. Some deformity is produced, and the adjustment of the wound cannot be so carefully carried out. The point is not of primary importance, and in dealing

with a large growth the knife may very properly be carried through the thickness of the lip.

Whenever possible, the symphysis should be saved. If it should be necessary to remove the median part of the bone with the genial tubercles, then the tongue must be prevented from falling back upon the larynx by means of a suitable silk ligature passed through its tip.

If the coronoid process be unduly long, or if it be pressed forwards by the growth of the tumour, it may hitch against the malar bone when the bone is depressed, and in such case must be divided with the chisel or bone forceps.

"In cases where the jaw has been extensively thinned or eroded by a growth, it is very likely to fracture under the depression which is required to bring down the condyle. If this accident occur, removal of the condyle and coronoid process is rendered difficult, as the latter is drawn upwards under the zygoma by the temporal muscle. The removal will be facilitated by dragging them down with lion forceps and detaching the temporal tendon with blunt-pointed scissors" (Jacobson).

In dealing with growths of the maxilla it is undesirable that any periosteum should be saved.

In excision for necrosis, however, it is important that as little of that membrane as possible should be sacrificed.

LIMITED EXCISIONS OF THE LOWER JAW

Considerable portions of the jaw, but more especially of the alveolar part of it, can be removed from the mouth. Such operations are frequently called for in dealing with some of the many forms of epulis. Such a segment as is shown in Fig. 301, H, can be readily removed. In effecting excisions of this limited character the chisel and mallet are the most useful instruments. Or the saw may be conveniently employed for the vertical incisions in the bone, and the chisel for the horizontal cuts.

It is well that the teeth in the involved segment should be removed, should any still remain. The surgeon will add greatly to the difficulties of the operation if he attempts to drive a chisel on a saw through the fangs of several teeth.

If a portion of the body of the bone has to be excised,

then it is always well to approach it by an incision made along the lower border of the maxilla.

Attempts to remove considerable segments of the body of the bone through the mouth are most unsatisfactory, lead to a needless mangling of the soft parts, to much bleeding, and to a sloughy pouch in the floor of the mouth.

The external incision enables the surgeon to reach the bone readily, to deal with it in the simplest manner, and to drain the wound cavity left after the excision.

Whenever possible, a portion of the lower part of the bone should be preserved, or, in other words, the lower border should never be divided unless it is inevitable.

If only a narrow bar of bone be left in this situation, it will prove of enormous value, not only in the after-treatment, but also in so far as the resulting deformity is concerned. The free use of the chisel enables much to be done in this direction.

If a portion of the maxilla through its whole width has to be removed, it is better, as Mr. Heath advises, not to complete one section before the other is begun, because of the loss of resistance consequent upon breaking the continuity of the bone.

Each cut should be carried nearly through the bone by means of the saw, and should then be completed with the bone-forceps.

REMOVAL OF THE WHOLE OF THE LOWER JAW

This operation has been performed in a fair number of cases. In Weber's table twenty cases are alluded to. The excision is reputed to have been first carried out by Blandin in 1848.

The procedure requires no special description. The vertical chin incision is omitted, and the knife is carried along the whole of the lower border of the jaw on both sides, and terminates posteriorly in the manner already described.

AFTER-TREATMENT

The general features of the after-treatment have been alluded to in dealing with the upper jaw. The main difficulty is to keep the mouth sweet. A large pouch is left in the floor of the mouth, and in this pouch food and the

secretions of the mouth must of necessity collect, and here they are apt to decompose. If no care be taken, this pouch becomes the seat of the foullest possible sloughs.

It is very difficult for the patient to wash the mouth out efficiently, as it is painful to move the remaining portion of the jaw, or even to move the head. The best wash is a 1 to 80 or 1 to 60 solution of carbolic acid.

The cleansing of the mouth is best effected by irrigation. For the first few days—if possible, for the first ten days—it will be well if the food can be administered through a tube, so that none can find its way into the mouth. If this be done, and if the mouth be washed out every hour with a gentle stream from an irrigator, the parts can be kept in excellent condition, and healing will proceed rapidly.

If a drainage-tube be employed, it should be removed in twenty-four hours, and the escape of the fluids in the mouth through the skin-wound should not be encouraged after that time.

The patient should occupy the sitting position as much as possible, and every care should be taken that he is well fed. In the manner of feeding we have usually employed the nasal tube, which has been passed after a little cocain had been introduced into the nose through a spray-producer.

The foulness of the mouth in a neglected case is indescribable, and the persistent attempt to avert decomposition is a main element in the after-treatment.

RESULTS

Results.—Mr. Butlin has collected 104 cases of excision of the lower jaw for tumour. Of these, fourteen died from the effects of the operation, showing a mortality of rather less than fourteen per cent.

The chief causes of death have been exhaustion, pyæmia, erysipelas, and lung complications. If the fullest antiseptic precautions are observed, this mortality should be much reduced.

Speaking of malignant growths (sarcomata) of the lower jaw, Mr. Butlin considers that the prognosis in subperiosteal sarcoma is, in spite of early and free operation, very bad, on account of the rapidity with which the disease involves the neighbouring structures, and recurs after removal.

In cases of central sarcoma the prognosis is not so bad, provided that the resection of the bone has been free, and especially when the growth is of the giant-celled or myeloid type.

OPERATIONS FOR THE RELIEF OF CLOSURE OF THE JAW

These operations are only adapted for severe cases which have resisted all milder measures, and in which the closure or the ankylosis is such as to cause grave inconvenience.

So far as the bone is concerned, two operations may be employed in dealing with this condition.

They are susceptible of modification, but they represent elementary principles in the treatment.

One operation would be ranked with cuneiform osteotomies; the other has been described as an excision of the temporo-maxillary articulation.

The two procedures are (1) Esmarch's operation, and (2) the removal of the condyle of the lower jaw.

1. **Esmarch's Operation.**—In this operation a wedge-shaped piece of bone is removed from the horizontal portion of the maxilla, with the intention of establishing a false joint.

This method is intended for those cases in which the trouble is *not* limited to the articulation. It is especially employed in examples of closure of the jaw due to the contraction of cicatrices. Such contraction is apt to follow destructive forms of inflammation, of which cancrum oris is a good example.

The *wedge* of bone to be removed must be taken from the horizontal ramus of the jaw, anterior to the masseter and in front of the contracted tissues. The base of the wedge will be below, and in an ordinary case in an adult should measure one inch and a quarter. The apex is at the alveolar border, and should be about three-quarters of an inch in width (Fig. 301, 1).

An incision some two inches in length is made along the lower border of the jaw at the spot at which it is intended to remove the wedge. The bone having been well exposed and the periosteum divided, a wedge of bone is removed with a keyhole saw, aided by the chisel and a periosteal elevator. After all bleeding has been checked the wound is closed by sutures.

It is essential that passive movements should be commenced

within a day or two of the operation, and should be regularly maintained. By means of screw gags and graduated pieces of cork the patient should be encouraged to open the mouth as wide as possible, and to cultivate active movements of the new joint. Unless care be taken in this matter, the trouble is very apt to relapse. If great pain be experienced in moving the jaw, then the passive movements may be practised under gas on the first few occasions.

Very good results have been obtained by this method, and very useful, though one-sided, masticatory power is obtained.

2. **Excision of the Condyle of the Jaw.**—This operation is identical with the so-called excision of the temporo-maxillary articulation.

It has been carried out in some instances of ankylosis following suppurative joint-disease. Usually, however, it has been applied to cases of chronic rheumatoid arthritis, with deformity and great impairment of movement, and to cases of closure of the jaw due to mischief limited to the articulation itself.

A vertical incision is made over the site of the joint and condyle. It is placed anteriorly to the temporal artery, starts at the lower margin of the zygoma, and ends below, just short of the transverse facial artery. The temporal artery may be considered to run about a finger's-breadth in front of the tragus, while the transverse facial artery is a little less than a finger's-breadth below the zygoma.

This incision may be joined by a second cut, which, starting from its upper extremity, follows the lower margin of the zygoma for about one inch.

The triangular flap thus marked out is reflected forwards. Care is taken not to damage any branches of the facial nerve nor any lobe of the parotid gland.

Such fibres of the masseter as come into view are separated from the zygoma, the capsule of the joint is exposed and opened, and the condyle brought well into view.

The neck of the condyle is now steadied by means of a small blunt hook, and is divided either with a chisel or a keyhole saw.

The condyle is then seized with forceps, and is twisted out with the left hand, while the surgeon severs any remaining

connections with a scalpel held in the right. Throughout the whole operation it is important that all instruments employed should be kept close to the bone.

If necessary, a little more bone at the base or root of the condyle may be removed, or it may be desirable to repeat the operation upon the opposite side. The fibro-cartilage is not removed. In some cases, the result of suppurative arthritis, the cartilage has been destroyed and true bony ankylosis has resulted. Then great caution must be used in chiselling, lest the cranial cavity be opened. (*See* paper by W. A. Lane, *Clin. Soc. Trans.*, 1895, page 1.)

A small drain may be introduced and retained for twenty-four hours, and the wound closed with sutures. Some slight and quite temporary facial paralysis may exist for some days after the operation.

The *after-treatment* advised in connection with the previous operation must be employed here.

Unless such treatment be perseveringly followed, the condition is apt to relapse.

The results obtained have been, on the whole, excellent.

There is nothing to commend the operation of removing the condyle through the mouth without external wound.

CHAPTER XVI

OPERATIONS ON THE SPINE AND SPINAL CORD

History.—Operations upon the spine in certain cases of injury are of some antiquity. In instances of fracture in which broken or displaced portions of bone were pressing upon the cord, the injured region has been exposed, and the fragments have been removed. This procedure, known usually as "trephining the spine," was attended, before the days of antiseptic surgery, with such lamentable results as to cause the measure to be regarded by many as totally unjustifiable.

One of the earliest of the more formal operations was carried out in 1814 by the younger Cline; the patient died. The method of treatment excited considerable notice, and drew forth much adverse criticism. A successful case operated upon by Sir W. Macewen in 1885 (*Brit. Med. Journ.*, August 11, 1888) marks a new era, and since then a large number of successful cases have been recorded.

Operations upon the spine in cases of paralysis due to pressure by inflammatory exudations, or displaced or deformed bone in Pott's disease, are of much more recent date.

On May 9th, 1883, Sir William Macewen removed the laminæ of the fifth, sixth, and seventh dorsal vertebræ in a case of complete paraplegia of two years' duration, depending upon angular deformity of the spine. The patient made a complete recovery. The cases of like character operated upon since that date have been numerous. Sir Victor Horsley reports seven as performed by himself, with one death from exhaustion at the end of six weeks (*Brit. Med. Journ.*, December 5, 1890).

A large number of cases of paraplegia following caries of the spine have been operated on by laminectomy, with the view of relieving pressure upon the spinal cord. The literature of the subject is very considerable. Out of twenty-three cases collected by Mr. Herbert Page (*loc. cit.*), an improvement more or less considerable followed in about half. M. Chipault (*Arch. Gén. de Méd.*, December, 1890) has brought together thirty-five cases of operation in Pott's disease, the examples of improvement showing a somewhat higher percentage.

Laminectomy for paraplegia due to the above cause has, however,

been largely abandoned in favour of conservative treatment by prolonged rest, etc.

The examples of operation for tumour have, up to the present time, been very few.

The writings of Sir Victor Horsley are especially valuable on this subject, and the same author records (*Brit. Med. Journ.*, February 27,

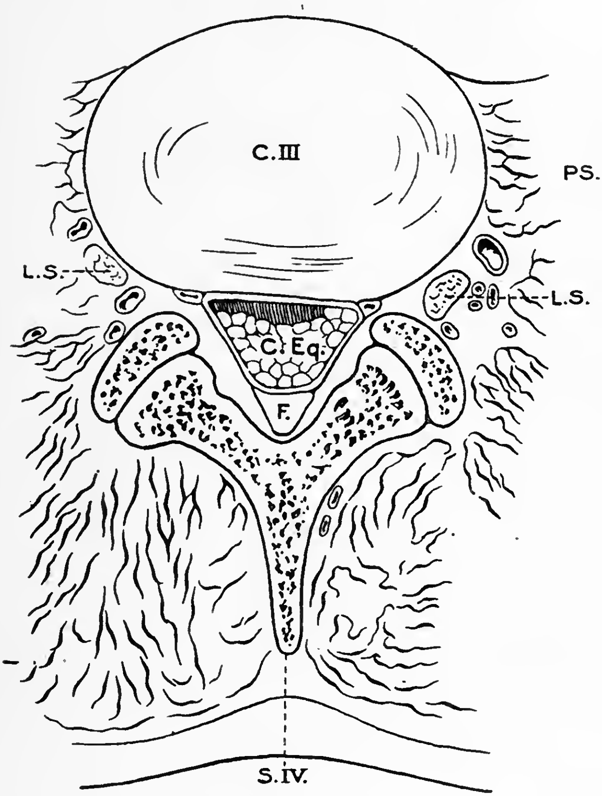

FIG. 303.—TRANSVERSE SECTION THROUGH THE CARTILAGE (C. III) BETWEEN THE THIRD AND FOURTH LUMBAR VERTEBRÆ.

C. Eq., Cauda equina; F., Fat behind the cauda equina; L.S., Lumbo-sacral cord; PS., Psoas muscle; S. IV., Spine of fourth lumbar vertebra.

1909) a series of cases of successful laminectomy for "chronic spinal meningitis," in most of which the presence of a tumour had been diagnosed but was not found. On this subject *see also* an important paper by Prof. Krause (*Verhandl. der deuts. Gesell. f. Chir.*, 1907, p. 598).

The surgeon interested in this branch of operative surgery should consult Thorburn's valuable work on "The Surgery of the Spinal Cord." Mr. Thorburn deals especially with the operative treatment of traumatic paraplegia, and he points out in how very few cases

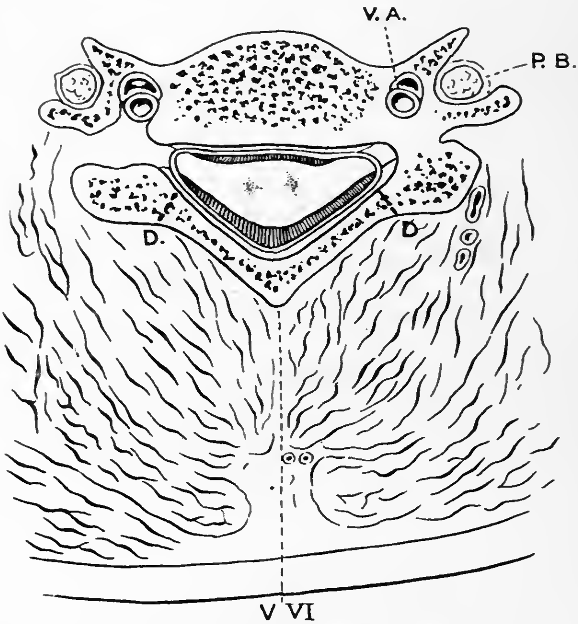

FIG. 304.—SECTION THROUGH THE SIXTH CERVICAL VERTEBRA TO SHOW THE RELATION OF THE CORD TO THE DURAL SHEATH, ETC.

D.D., Section of posterior laminæ required in laminectomy; V.A., Vertebral artery and vein; P.B., Root of brachial plexus.

laminectomy can be expected to improve the patient's prospects of recovery.

Monographs by Schlesinger (1898) and Oppenheim (1907) in German on Tumours of the Spinal Cord, etc., and by Spiller and Martin (*Pennyslvania Med. Bull.*) on Spinal Meningitis, should be mentioned here.

Instruments Required.—Stout and fine scalpels; trephine; bone-cutting forceps of several shapes; rugine; elevator; necrosis forceps; chisel and mallet; retractors; blunt hooks; probe; Volkmann's spoons; fine tenaculum-pointed forceps; fine scissors; small curved needles and needle-holder; straight needles; ligatures; sutures, etc. Sir V. Horsley has devised a

special form of angular cutting forceps for dividing the laminæ. Doyen's guarded saw is recommended by some.

The Operation.—One of the most lucid accounts of the operation is that given by Dr. William White, and it has been, to a great extent, followed in the appended description :—

The patient lies in a prone or semi-prone position, and a gentle curve is given to the spine by means of a small hard pillow placed under the lower ribs.

A long incision is made in the median line, exactly over the spines of the vertebræ, in the region it is desired to expose.

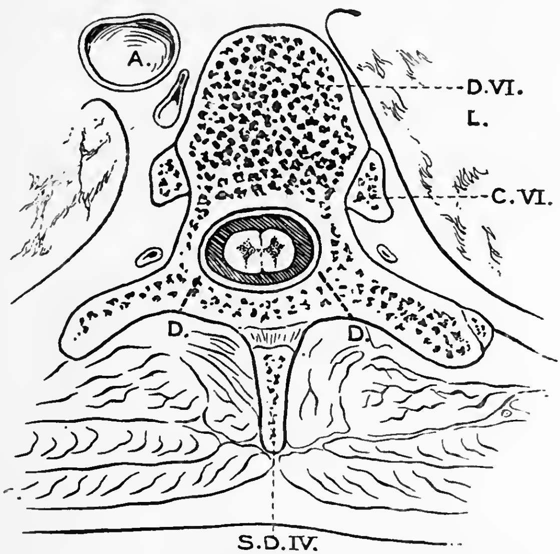

FIG. 305.—SECTION THROUGH THE SIXTH DORSAL VERTEBRA.
C. VI., Sixth rib ; S.D. IV., Spine of fourth dorsal vertebra ; L, lung ; D.D., as in Fig. 304.

The incision is carried deep down, and the muscles are freely separated from the sides of the spinous processes and the posterior surfaces of the laminæ by the knife, aided by the rugine. One side is cleared, and all the bleeding arrested, before the other side is exposed in like manner.

A considerable portion of the spine being now exposed, the periosteum is divided along the angle between the spinous processes and the laminæ, and is then reflected from the surfaces of the vertebral arches by means of a curved rugine. Firm

rectangular metal retractors are needed at this stage of the operation. Sir V. Horsley divided the deep fascia at right angles to the line of the incision in one or more places. Gordon severed the muscular bundles attached to the articular processes, in order to obtain a fuller view of the neural arches.

The spinous processes are now divided close to their bases by means of large, strong, bone-cutting forceps, with blades set at an obtuse angle. It is now necessary to divide the laminæ on each side, in order to expose the vertebral canal. Some surgeons have used a trephine for the purpose—a not very convenient instrument; others have employed Hey's saw, or the chisel and mallet, or bone-cutting forceps. The method employed must depend upon the surgical habit of the individual surgeon. Doyen's saw, which is practically a Hey's saw armed with a guard, is certainly useful. A deep groove may be cut with this and the section completed with the chisel.

In any case, some trouble may be anticipated from the very tough ligamentum subflavum. The laminæ should be divided as near to the transverse processes as possible. When the neural arch has been removed to a sufficient extent, the dura mater is well exposed. The operation may end here. The excision of the laminæ may have removed the injurious pressure from the cord, or displaced fragments of bone may require to be taken away, or pus or an extradural collection of blood may be evacuated, or an extradural tumour may be excised.

The hæmorrhage in this part of the operation has never been so extensive as arguments based upon theoretical grounds had predicted. It has been in nearly every instance easily and permanently arrested by moderate pressure.

If it be determined to open the dura mater, it is seized in the middle line with fine tenaculum-pointed forceps, and is opened vertically—either by a small scalpel, or, better, by means of fine scissors. When the divided parts are retracted upon either side, the whole of the posterior surface of the cord is well exposed.

Any tumour detected is dealt with by simple excision. The most favourable form of tumour—unfortunately the least common—is a non-infiltrating growth of the dura (e.g. a psammoma or

endothelioma) which is affecting the cord solely by pressure (Fig. 306). If it should prove that the tumour is an infiltrating sarcoma there is little or no object in attempting its complete removal. If the condition should prove to be excessive effusion with thickening of dura mater and more or less sclerosis of the cord

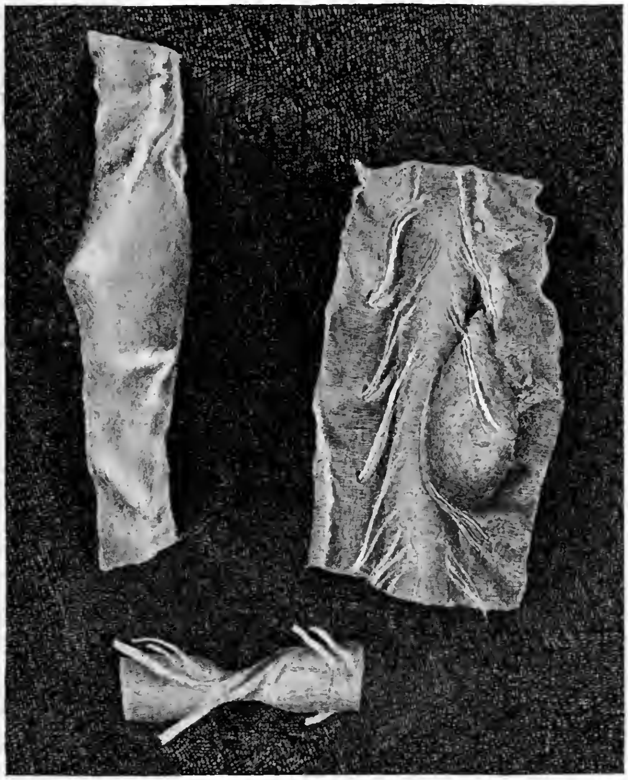

FIG. 306.—TUMOUR OF DURA MATER, OF NON-MALIGNANT NATURE (A PSAMMOMA).

The unopened dura mater is seen on the left, the relation of the cord and nerves to the tumour on the right, whilst the cord is shown below, atrophied from simple pressure. In this case very severe girdle-pains with gradual spastic paraplegia were the chief symptoms.

(as in Horsley's and Krause's series of cases already referred to), the fluid is let out and a solution of 1 in 1,000 bichloride of mercury used for irrigation (Horsley). The value of this latter procedure is open to question, as the mercury is quickly washed away by the cerebro-spinal fluid.

If the operation has been done for traumatic or kyphotic paraplegia, just enough bone should be removed to free the cord from pressure.

If caries with tuberculous thickening or abscess be found, one or more transverse processes may be cut away and a small Volkmann's scoop used with caution to the diseased area of bone.

The opening in the dura mater may be sutured in part with fine catgut, introduced by means of a curved needle in a needle-holder. Sir Victor Horsley has largely given up the practice of sewing up the theca, and he also recommends that the superficial wound should be completely closed and not drained. The presence of a drainage-tube may possibly lead to inflammation, and the escape of cerebro-spinal fluid into the tissues about the spine appears to be beneficial rather than otherwise. Still, if the theca has been extensively incised, it is advisable to close it partially at least.

The muscles are brought together by catgut sutures; after which the superficial parts are united by sutures of silkworm gut.

The length of time during which the patient must remain in the recumbent position will depend upon the nature of the case, and the extent and character of the operation. It will usually be advisable that a spinal jacket or spinal support should be worn for some little time after the patient gets up.

Comment.—The operation of laminectomy appears to have given the best results in cases of "chronic meningitis with effusion" of obscure causation. For paraplegia due to caries of the spine it should rarely, if ever, be performed. For gunshot injuries it is practically useless, and for other traumatic cases its value is very doubtful. The most favourable cases are those in which the injury has been a direct one, and the paralysis incomplete, especially in the lumbar region.

A few brilliant cases of operation for spinal tumour have been recorded, but the mortality of the operation is considerable. Judging by the best recent statistics (Putnam and Warren, Dr. J. Collins and Dr. Harte of Philadelphia, Prof. Krause, etc.) the deaths amount to nearly 50 per cent. Really successful removal of the tumour has been effected in 30 per cent. or less of the cases.

PART IV.—OPERATIONS ON THE THORAX AND BREAST

CHAPTER I

OPERATIONS ON THE THORAX

Anatomical Points.—The ribs are placed so obliquely that the anterior end of one rib is on a level with the posterior end of a rib some way below it in numerical order. Thus the first rib in front corresponds to the fourth rib behind, the second to the sixth, the third to the seventh, the fourth to the eighth, the seventh to the eleventh. If a horizontal line be drawn round the body at the level of the inferior angle of the scapula while the arms are at the side, the line would cut the sternum in front at the attachment of the sixth cartilage, the fifth rib at the nipple line, and the eighth rib at the vertebral column. The second rib is indicated by the transverse ridge on the sternum. The lower border of the pectoralis major leads to the fifth rib, and the first visible serration of the serratus magnus corresponds to the sixth.

The intercostal spaces are wider in front than behind, and between the upper than the lower ribs. The widest of the spaces is the third, then the second, then the first. The narrowest spaces are the last four. In normal conditions the first six spaces are wide enough to admit the whole breadth of the index finger.

Beyond the angle of the rib the intercostal vessels lie in a groove on the inferior border of the rib forming the upper boundary of a space. The vein lies nearer to the rib than does the artery.

The lower border of the lung corresponds to a slightly convex line drawn round the chest from the sixth chondrosternal articulation in front to the eleventh dorsal spine behind. In the mammary line this would correspond to the sixth rib, in the mid-axillary line to the ninth rib, and in a line continued vertically downwards from the inferior angle of the scapula with the tenth rib. The pleura extends farther down than the lung, reaching in front to the level of the seventh chondrosternal union, behind to the eleventh dorsal spine, and at the sides to a point some two and a half inches above the

lower margin of the thorax. The pleura is in relation with the eleventh rib posteriorly, but not usually with the twelfth.

The following **operations** will be described :—

1. Incision of the thorax, with or without resection of a portion of rib—Thoracotomy.
2. Esthlander's operation—Thoracoplasty.
3. Operations on hydatid cysts of the lung.
4. Incision and drainage of the pericardium.
5. Treatment of spinal and other large tubercular abscesses.

1. INCISION OF THE THORAX—THORACOTOMY.

This operation is carried out in cases of empyema. It consists in opening the suppurating cavity and draining it.

As a surgical measure, it differs in no essential from the ordinary method of treating purulent collections elsewhere, i.e. by free incision and drainage.

Site of the Incision.—This must be influenced obviously by the physical signs afforded by the empyema.

If pus be actually pointing at any one spot upon the surface, the incision may be made there, even if it be necessary to make a second wound to afford more complete drainage.

The sites commonly selected are the sixth or seventh space, just in front of the posterior fold of the axilla, the fifth space immediately external to the cartilages, and the eighth or ninth space just external to the line of the angle of the scapula. The latter situation is the one most usually advised. In children it is perhaps always the best, while in adults it is usually the most favourable.

As Mr. Godlee points out, an opening in the lowest part of the space where the cavity is soonest obliterated is less efficient than one made higher up, opposite to the part of the cavity which is the last to close.

The opening in the sixth or seventh space at the point indicated has the advantage afforded by a very thin covering of soft parts.

The Operation.—The skin around the site of the operation must be well cleansed and thoroughly disinfected.

Chloroform is the best anæsthetic. It should, however, be

given with great caution; a small amount usually suffices. Chloroform, one part, and ether, two parts, is less depressing to the heart, and is often employed instead of chloroform. Ether alone is apt to excite coughing in chest cases, and is therefore not suitable. When the condition of the patient is specially unfavourable, local anæsthesia by means of eucain may be chosen, but this will not prevent the pain involved in the excision of part of a rib.

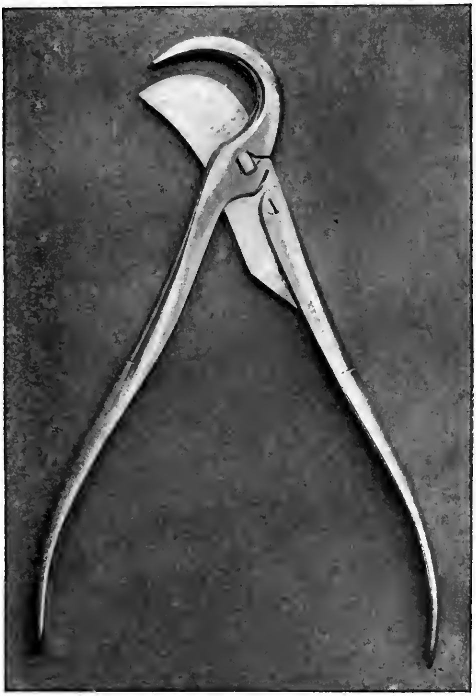
FIG. 307.—POLLOCK'S RIB SHEARS.

The patient is brought to the extreme edge of the table, and is allowed to lie as nearly as possible upon the back.

It is more convenient to the surgeon if the patient be rolled over upon the sound side; but such a position is apt seriously to interfere with the breathing, especially when the patient is under the influence of the anæsthetic.

The arm must be raised, but not beyond a right angle. The lifting of the arm involves a displacing upwards of the skin. Before making his incision the surgeon must note to what extent the integument is displaced by raising the limb, and must make his incision so far above the spot at which it is intended to divide the intercostal muscles as will correspond to that spot when the limb is brought to the side. It is essential that the incision be not valvular, and that the opening into the thorax be quite direct, the skin wound and the deeper wound exactly corresponding.

An incision, from one and a half to three inches in length, is made transversely, so as to correspond to the upper border of the lower rib bounding the space.

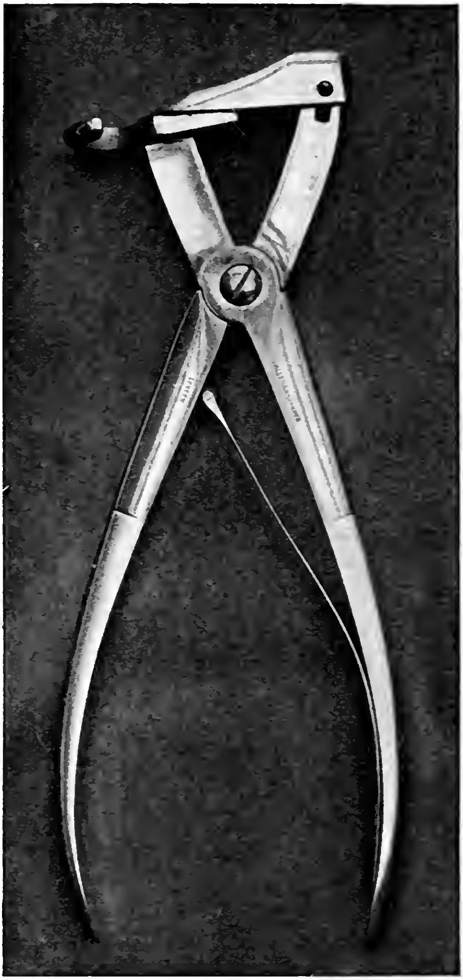

FIG. 308.—SCHUMACHER'S RIB SHEARS.

The intercostal muscles are divided close to the rib. The periosteum is freely incised and peeled off the bone round its whole circumference.

It is important to detach the periosteum and pleura on the inner side intact, so that pus may not escape until the rib has been resected. At least one inch of the bone should be removed. The best instrument for this purpose is the special curved resection shears (Fig. 307).

The intercostal vessels and nerve have been detached with the pleura. The latter is now incised above these, and the opening enlarged if necessary with dressing forceps.

As soon as the drainage tube is inserted the patient should be turned so that the opening is dependent.

The pus, if considerable in quantity, should be allowed to escape slowly. The abscess cavity may be examined with the forefinger as the fluid is escaping, or after it has been entirely evacuated. All thick curdy material within reach of the finger should be removed.

Experience has shown that it is unwise to wash the cavity of the empyema out at the time of the operation. All that can be done at first is to provide a free opening for the escaping pus.

If for any reason the incision has not been quite conveniently placed for drainage, a counter-opening lower down in the thorax should be made.

A steel bladder-sound, or other suitable instrument, is introduced into the incision, and its point is made to project in one of the lower spaces. Upon the instrument thus held, a cut with the knife is made. Two drainage-tubes should, in such cases, be inserted. There is nothing to recommend the plan of passing a single tube from one opening to the other.

The drainage-tubes employed should be large and not too rigid. They should not be inserted at great depth. It is only necessary that their open ends should project into the pleural cavity, and that they should not impinge directly upon the lung. No object can be served by a long drainage-tube.

A great and remarkable variety of drainage-tubes has been employed for these cases. They have been made of very varied materials, and in very varied shapes.

It is important that the tube should have no lateral openings, as otherwise the pus may be forced into the subcutaneous tissues and set up a severe cellulitis. For the same reason it is well to protect the edge of the wound from the constant flow of pus by placing a piece of oiled silk between the skin and the opening of the tube.

Above all things, it is most necessary that the tube be well secured, and that every precaution be taken to prevent it from slipping out of sight into the pleural cavity. This accident has occurred over and over again. Flanged tubes, tubes with shields, or tubes held in place by sutures and "buoyed" by long ligatures, are consequently to be recommended.

A convenient method of preventing a drainage-tube from slipping in consists in slitting it longitudinally for an inch or more, turning each of the halves outwards and keeping them so with a safety-pin. To encourage the lung to dilate by preventing air from entering the pleural cavity, several forms of tube with valvular orifice have been introduced, especially for use in the

late stage of an empyema. The principle of the valvular orifice —allowing pus to escape, but preventing the entrance of the air—is certainly right, but in practice we have not seen any special advantage resulting from the use of these tubes.

In removing every dressing during the after-treatment, the first care should be to note the position of the drainage-tube. In more than one case an extensive operation has been carried out in order to search for a chimerical drainage-tube, reported to be in the pleural cavity, but, in reality, thrown away with the dressings.

If during the operation an intercostal artery be cut, the surgeon's first care should be to see that the vessel is entirely severed, and not partly divided. Probably the most serious hæmorrhage in these cases comes from partly-divided arteries. If cleanly cut, the little vessel soon retracts. Failing this, pressure may be kept up for a while with the finger or a plug of fine sponge.

After the tube is in place the skin is cleansed and the dressing applied. The dressing must be of considerable proportions, and may consist of a loose pad of fine gauze. This may be powdered with iodoform. Over the whole is placed a covering of protective or oiled silk, or fine waterproof sheeting, secured in place by a bandage.

The dressing will need to be changed frequently.

When the discharge has subsided a little, and especially when the escaping matter is offensive, the empyema cavity may be washed out once or twice daily. This is best done by means of a funnel and long tube. A very weak antiseptic solution, at a temperature of about 100° F., should be used. The most usual injections are solutions of corrosive sublimate, 1 in 8,000; of tinctura iodi, 1 in 1,000; and of boric acid—a cold saturated solution made warm. In many cases this irrigation is not required, and if it is done, the fluid should be allowed to flow in without any force. A convenient method is to fix a rubber catheter into the end of the irrigator and to pass the former through the empyema tube so that its end projects just into the abscess cavity. A solution of peroxide of hydrogen is a useful mild antiseptic for the purpose.

Later in the progress of the case a counter-opening may be called for, should none have been made at the time of the operation.

As a considerable proportion of cases of empyema are really tuberculous in nature, delayed healing is very apt to occur. The patient should be got into the open air as much as possible, and sometimes a stay at the seaside will lead to healing of the sinus. Lung-exercises, such as blowing air through a tube into a bottle of water, should be employed daily to get the lung to expand.

Occasionally the sinus is prevented from healing by partial necrosis of the edge of rib. This may necessitate a second operation for removal of the dead bone. If after a lengthy trial the lung will neither expand nor the chest wall contract sufficiently, Esthlander's operation (*see* page 310) may be required.

Drainage of Empyema without Resection of Rib.—We have already stated our belief that an empyema can hardly be drained satisfactorily without removing part of a rib, a procedure which adds practically nothing to the gravity of the operation. At the same time, if the intercostal space is particularly wide at the spot selected, the attempt may be made to do without resection. Mr. G. B. Turner has introduced a special silvered tube with a sharp-pointed trocar for this purpose. It is like a laryngotomy tube, but is flattened from above downwards, so as to pass readily between the ribs, and has a metal flange. A short incision through the skin over an intercostal space is alone required, the trocar and cannula being then thrust through the muscle and pleura. The operation can be done under ether spray or eucain, but this seems to be its only advantage. Drainage through the flattened tube is not good, nor is a rigid metal one at all comfortable for the patient to wear.

It need hardly be said that exploratory puncture with an aspirator needle is most useful in determining the presence of an empyema, and it is best, when the operation for drainage is carried out, to have an aspirator ready to make the diagnosis certain before resecting the rib. Many times, however, the operator has been deceived by the use of too small a needle or cannula, through which the pus, though present, is unable to escape.

2. ESTHLANDER'S OPERATION—THORACOPLASTY

This operation is carried out in certain cases of empyema of long standing—cases in which no healing follows, in spite of long-continued and free drainage of the purulent cavity.

In such instances the chest walls have contracted to their utmost, the lung lies unexpanded, the pleura is greatly thickened, and although the diaphragm has risen to an exceptional position, there still remains a cavity with rigid walls which can contract no further, and which could never close by the slow and exhausting process of granulation. The operation is a plastic measure, which has for its object the speedy obliteration of this cavity. This is effected by cutting away the rigid part of the wall of the space—i.e. the whole of its costal boundary.

Extensive resection of ribs is now much less resorted to than when the operation came first into vogue. We have learnt how frequently it fails of its object, whilst, on the other hand, with patience it can usually be dispensed with. The shock attending the operation is usually severe, and the patient is in a very poor condition to undergo it, hence the mortality is high. Even if the operation is successful, the chest is left deformed and a lateral curvature of the spine is the result. In a case of empyema with long-standing sinus, regular respiratory exercises to promote expansion of the lung and the best hygienic surroundings will almost always prevent the resort to Esthlander's operation.

Esthlander, who paid especial attention to the removal of ribs as a plastic measure, published his account of the operation in 1879 (*Rev. Mens. de Méd. et de Chir.*).

The Operation.—The patient having been placed in position and anæsthetised (*see* page 305), the cavity to be treated is thoroughly examined, its full extent is ascertained, and the condition of its interior is determined.

The cavity will be found in the upper or central parts of the pleural space, rather than in the lower.

A special operation must be planned for each case, and it is impossible beforehand to determine how many ribs will have to be resected, or how much of each one will have to be removed. Success depends upon the removal of the whole of the unyielding bony wall of the cavity, and the limits of the excision are identical with those of the suppurating hollow which has to be closed. As soon, therefore, as the extent of the cavity is known the extent of the excision is defined.

The ribs usually removed are the second, third, fourth, fifth, sixth,

and seventh. The amount excised will vary from an inch or so to nearly the whole length of the bony part of the rib. In the case of a female aged twenty-five, Mr. Pearce Gould removed considerable lengths of the ribs from the second to the ninth inclusive. The total length of bone resected was fifty-four inches, giving an average of six inches to each rib. The pleura in this case was nearly an inch thick.

Various plans are adopted for exposing the costal walls. Mr. Godlee recommends a flap composed of all the soft parts covering the ribs. This flap is marked out by a **V**-shaped or **U**-shaped incision, and is free below, so as to allow for drainage. This procedure is somewhat serious, involves a great wound, and possibly much hæmorrhage.

Esthlander makes a transverse cut over the centre of an intercostal space, and through this wound excises portions of the two ribs which bound the space. If, therefore, six ribs have to be removed, three of such incisions will be called for.

Jacobson advises the formation of two, three, or more small flaps. Gould recommends a vertical incision over the central part of the cavity, and this, probably, will be found as convenient a way of exposing the ribs as any.

Each rib is exposed in turn, and is bared of periosteum with the curved rugine. It is then excised in the manner already described (page 306). The periosteum is removed after each excision.

"If the cavity extends far back towards the spine," writes Mr. Gould, "it will be found convenient, after removing the front portion of the rib in the usual way, to remove the posterior part from the inside, peeling the thickened pleura off the bone, and applying the cutting forceps from within the chest. The dense cicatricial tissue which will usually be found lining the ribs, and the greatly-thickened pleura must be cut away with scissors and forceps."

The hæmorrhage attending the operation is often considerable, but is readily controlled.

The operation should be completed with as little delay as possible.

The cavity should be then washed out with warm saline solution or boiled water. Very small cavities may be stuffed with fine gauze, and allowed to close up from the bottom.

In dealing with the ordinary cavity, the skin is brought into place by silkworm-gut sutures, and the wound thus closed. A large drainage-tube is introduced into the most dependent part of the cavity; or, if necessary, a special drainage incision may be made.

The operation usually produces much shock, and rectal injections of warm saline solution and brandy may be required.

There is nothing especial to note in the **after-treatment.** It is

that of an extensive and deep wound made in tissues that have been long the seat of inflammatory action.

The Incision and Drainage of Cavities in the Lung.—The treatment of hydatid cysts is described below, but with regard to operative interference in tubercular cavities, those due to bronchiectasis or to gangrene of the lung, it is unnecessary to say much here. The results have been on the whole most disappointing, for obvious reasons. A tubercular cavity or a dilated bronchus is rarely if ever single, the mechanical difficulty of draining is great, disinfection almost impossible.

The experience derived from a large number of attempts during the last twenty years has led to the conclusion that surgery has no place in the treatment of tuberculosis of the lung or of chronic bronchitis. Occasionally it may be worth while to cut into a cavity due to pulmonary gangrene, provided one lung only is affected (a rare limitation, met with in cases in which a foreign body has lodged in a bronchus). The procedure in such a case will present nothing calling for special comment.

3. OPERATIONS ON HYDATID CYSTS OF THE LUNG

The opportunity of operating on these cysts of the lung is very rarely afforded to surgeons in England. Thus in twenty years' surgical experience one of us (J. H.) has only operated on three such cases, in two with complete success, the third resulting in death owing to the hydatid cysts being scattered over both lungs.

In Australia hydatids of the lung are met with much more commonly than in Europe, and the following account of the operation has been written for this work by Dr. W. Gardner of Adelaide, whose experience of the disease has been very large.

The main principles are the same as those laid down with regard to hydatids of the liver, and the reader is referred to Vol. I., pages 128 to 137. It should be noted, however, that irrigation of the cyst cavity, which is safe and often most useful in the case of hydatids of the liver, is attended with much risk in the case of the lung. The fluid may be carried straight into the bronchi, trachea, and other lung, and the patient suffocated, or rather drowned.

As regards the diagnosis of hydatid cyst of the lung, much stress should be laid upon the radiographic appearances. Such a cyst, if single, should show a well-rounded outline for its upper border. This convexity is never seen in abscess of the liver, new growth, etc.

Again, the blood should always be examined in any suspected case

of hydatid, as eosinophilia is always present in greater or less degree.

The following is Dr. Gardner's description of the actual operation :—

"The site of the cyst having been mapped out by auscultation and percussion as carefully as possible, an incision about four inches long is then made in the line of the ribs through the skin, which is retracted by means of two loops of silk passed through the divided edges. The periosteum over two ribs is then divided and peeled off with a raspatory, and at least three inches of the ribs are removed. Any bleeding points must now be ligatured or twisted, and all oozing stopped by sponge pressure.

"The next step in the operation is to pass a long and fine trocar and cannula in the direction in which the cyst has been localised. If this fail, the needle must be driven in again, altering the direction ; but this is rarely required. It must then be noted at what depth the cyst is reached, as evidenced by the escape of clear fluid, or of pus if suppuration has occurred. To facilitate this step, the trocar should be marked off in inches and quarter-inches. If not so marked the finger must be used to measure, as the cannula is withdrawn, the distance to which it penetrated.

"A long narrow-bladed knife must then be thrust in the same direction into the cyst, and an incision large enough to admit two fingers rapidly made. Two fingers of the left hand are then introduced and the cyst hooked up, the knife laid down, and a curved needle, which is held by an assistant, and threaded with kangaroo tendon or silk, is passed through the cut edge of the cyst, visceral and parietal layers of the pleura and intercostal muscles, and handed to an assistant, but not tied. The same manœuvre is then repeated on the side which is held up by the fingers of the left hand ; and this loop is also held, but not tied.

"If the cyst be situated at the base of the lung, a drainage-tube must now be passed into the pleura by the side of the cyst ; but if it is situated higher up, it is better to take out a piece of rib in a convenient situation, and pass a drainage-tube into the bottom of the pleura. The two stitches are then tied, and several others inserted in the same way and tied at once. With the finger as a guide, a pair of rat-trap forceps are introduced, and made to take hold of the mother-cyst. The finger is then withdrawn, and, with the forceps in the left hand, the surgeon gently draws on the cyst—and as it frequently tends to break, he must be prepared with another pair of strong catch-forceps to take a fresh hold—and a little delicate manipulation will deliver the mother-cyst entire. In the process of removal,

the rent in the mother-cyst may allow daughter-cysts to escape into the cavity; but it is better to allow them to be washed out later by douching than to run the risk of injury to the wall of the external capsule. A large drainage-tube is then introduced into the cavity, and the extremities of the skin incision are approximated by sutures of gut or horsehair."

We would again emphasise the danger of washing out the cavity, owing to the fact that the cyst may have already opened into a bronchus.

The separate drainage of the pleural cavity described by Dr. Gardner may usually be avoided.

In grasping the wall of the mother-cyst a pair of long-handled sponge forceps will be found quite as convenient as the rat-trap forceps mentioned by Dr. Gardner.

4. INCISION AND DRAINAGE OF THE PERICARDIUM IN PURULENT PERICARDITIS

The literature of the subject is copious. Among the fullest and best papers are those by Dr. Samuel West (*Med.-Chir. Trans.*, vol. lxvi., page 260, and *Brit. Med. Journ.*, Feb. 21st, 1891); Mr. T. P. Rowlands (*Brit. Med. Journ.*, Jan. 2nd, 1904); Mr. Eliot, *Annals of Surgery*, January, 1909).

The amount of pus evacuated has in some cases been remarkable. In one of Dr. West's cases "fully two quarts" were evacuated in a few seconds.

The pericardial sac is more safely opened by means of an incision than by means of aspiration in cases of suppurative pericarditis.

Aspiration may be resorted to in those not very infrequent cases where doubt is felt as to the purulent nature of the effusion. The fifth or sixth left interspace, preferably the latter, or the left costo-xiphoid angle may be selected for the point of entrance of the needle. If the last-named spot be chosen, the trochea or aspirating needle must be directed upwards and backwards.

In any case great care must be taken not to thrust the point in too far, as fatal wounds of the breast have been thus inflicted.

The procedure for drainage of the pericardium is as follows:—

The incision is made in the fourth or fifth intercostal space of the left side, and about one inch to the outer side of the edge of the sternum, in order to avoid the internal mammary artery.

The incision is at first small, and is cautiously deepened. The opening in the pericardium may be at first a mere puncture, and may then be enlarged by cutting, or dilated with sinus forceps.

When all the pus has escaped, a soft drainage-tube is inserted. The cavity exposed must be kept well drained, and should be well washed out as often as required. The after-treatment differs in no essential from the after-treatment of purulent collections elsewhere.

In many cases a portion of rib has been excised in order to give more free access to the pericardium. It is desirable to avoid opening the left pleural cavity, and as the fluid collects chiefly below the heart, Deguy (*Journ. des Praticiens*, 1902, page 36) advises the following operations:—

1. Median incision directly over the xiphoid cartilage.
2. Subperiosteal resection of this part of the sternum, followed by downward detachment of the muscular fibres of the diaphragm.
3. The pericardial sac is exposed by dissecting through the loose cellular tissue; it is seized by fine-pointed forceps and drawn down.
4. Incision of the pericardium, followed by drainage with gauze or tube.

The late Mr. H. W. Allingham advised a similar proceeding, except that the xiphoid cartilage was not resected. The wound in his case was made through the top of the left rectus muscle (across its fibres); the cellular interval between the sternal and costal parts of the diaphragm was then sought for, the peritoneum being pushed downwards and the pericardial sac thus reached. A good-sized artery, the superior epigastric, is in considerable risk of being wounded; and this fact, together with the time occupied in either Deguy's or Allingham's procedure, constitutes an objection to both. At the same time the drainage afforded at this spot should be very favourable.

Nothing would be gained by describing the number of modifications that have been suggested by different writers. Probably the worst of these consists in making a flap of rib-cartilages and overlying soft parts, which is turned aside to expose the pericardium.

Eliot advises that the edges of the divided pericardium should be sewn to the skin when possible, but we cannot see that any great advantage is to be gained from this. More important is it to make certain that the drainage-tube should not irritate the heart. The tube should be as flexible as possible (the spiral tube is the best in this respect), and no longer than is necessary.

Result of the Operation.—The condition of pyo-pericarditis is so extremely grave, being usually only a symptom of general pyæmia, that drainage is not often followed by recovery. The statistics, such as are given by Eliot, are commonly based on isolated successful cases which have been published, and are wholly misleading.

Nevertheless drainage is worth attempting in any case of pyo-pericarditis if the patient is not actually moribund.

5. THE TREATMENT OF SPINAL AND OTHER LARGE TUBERCULOUS ABSCESSES

The surgeon should aim at removal of all the tuberculous lining membrane, at closure of the cavity (without drainage if possible), and at obtaining perfect rest of the part until healing occurs. No irritating antiseptics should be used for washing out, and no foreign substance such as iodoform should be left in the cavity. If carious bone has led to the formation of the abscess it should be gouged or cut away; thus a tuberculous abscess of the chest wall may require resection of one or more ribs. Unfortunately this indication cannot be carried out in cases of psoas or other spinal abscess; nevertheless the best results are obtained here by following the lines of treatment given above, and by keeping the spinal column at rest by suitable apparatus or by prolonged recumbency.

As an example, we will suppose the case of a large abscess about the hip, due to disease of one of the bursæ in this region. An incision is made into the abscess free enough to expose every part of its cavity, its wall is then cut or scraped away with scalpel, scissors, and sharp Volkmann's scoop. Every pocket of the abscess is opened up and freely scraped. An electric head-lamp will be found most useful in securing this. The muscles over the abscess wall are spared as far as practicable

by making the incision between their fibres, the edges of the wound being well retracted. If the great trochanter is found to be carious the gouge should be used to the base surface until healthy bone is exposed. An irrigator containing some gallons of sterile water (at the temperature of 100°) is then employed to all parts of the cavity. Mr. A. E. Barker's flushing curette is sometimes used, but may be dispensed with. After prolonged irrigation the cavity is dried by sterile swabs or sponge-holders. The swabs should be inspected and the process continued until they are seen to be entirely free from particles of tuberculous membrane. Loose shreds of aponeurosis or other fibrous tissue should be carefully dissected away.

When the operator is satisfied that all traces of the abscess wall have been removed, the cavity may be swabbed out with a sponge dipped in adrenalin solution (1 in 1,000) to check oozing. A drainage-tube is then temporarily placed in the cavity, and over it a few deep sutures of catgut or kangaroo tendon may be inserted to bring together parts of muscle that have been separated, etc. Finally the skin and fascia are sutured with silkworm gut, the cavity entirely emptied by pressure, and the drainage-tube withdrawn. A large soft dressing of sterile gauze and wool is applied over the whole region and kept in position by ordinary bandage and elastic webbing.

The patient is kept at complete rest for ten days or so, when the dressing is changed and the sutures removed.

In a fair proportion of cases the abscess will re-form, perhaps as thin, semi-purulent fluid, and aspiration followed by pressure may suffice for cure. Or the same procedure may be repeated.

It is unnecessary to insist on the value of open-air life, good food, etc., for the subject of tubercular abscess.

CHAPTER II

OPERATIONS ON THE BREAST

Anatomical Points.—The female breast normally extends from the third to the fifth or sixth rib vertically, and from the edge of the sternum to the outer border of the pectoralis major transversely. Its size, however, varies greatly in different individuals and at different ages. At the period of life when scirrhus most often attacks it (forty to fifty years), the margin of the breast is often ill-defined, and its peripheral lobules are difficult to distinguish from the surrounding fat.

Processes of the gland extend towards the skin, to which they are held by fibrous bands (the suspensory ligaments of Sir Astley Cooper). In Fig. 309 it is seen that these processes are separated from each other by fat, and that they frequently come close to the skin (*see* 6 and 7 in the figure). Hence the importance, during an excision of the entire cancerous breast, of removing the skin over it freely. On its deep aspect the breast lies closely on the pectoral fascia, in which a cellular interspace allows of lateral mobility and also facilitates the detachment of the breast during the operation from the chest wall. It should be noted that this interspace in the fascia (*see* 11, 12, and 13 in the figure) is freely supplied with lymphatic vessels, which communicate with those of the breast. Hence in the operation it is best to remove the whole of this fascia with the underlying pectoral muscle.

If the whole thickness of the muscle be not removed, at least the surface fibres should be, so as to make sure of excising the fascia and the lymphatics in it.

The breast is supplied by the following arteries, which are divided in excision of the gland, viz. the second, third, fourth, and fifth intercostal branches of the internal mammary (*see* Fig. 310, Nos. 1, 1′, 1″). Of these, the branch coming through the third interspace is often of comparatively large size. All these vessels

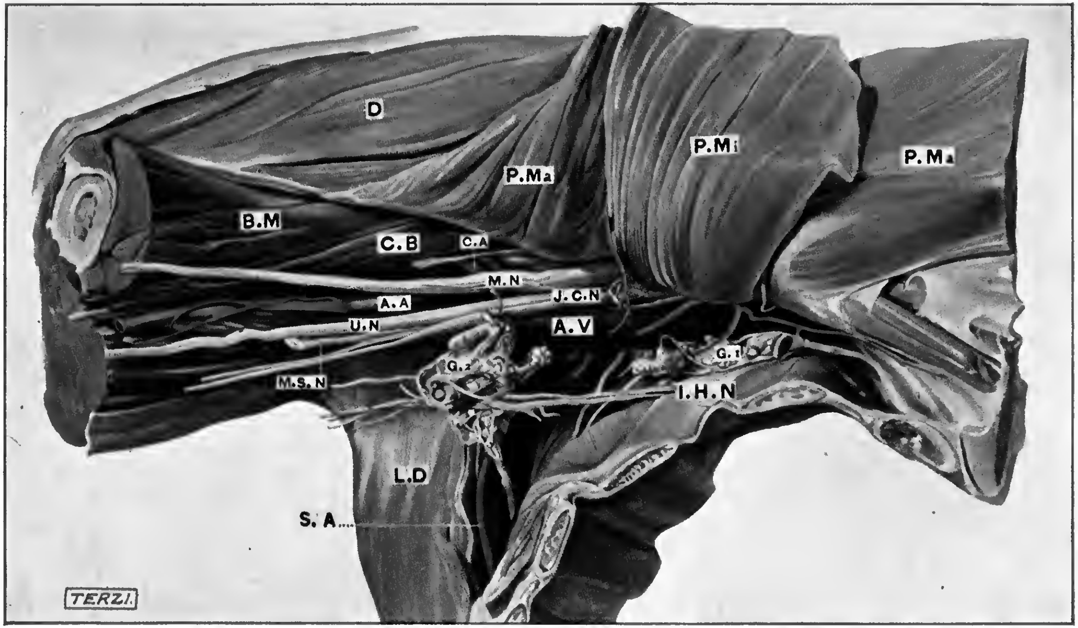

PLATE XX.—DISSECTION OF THE AXILLA AND UPPER ARM.

(From a Dissection in the Museum of the London Hospital Medical College.)

TWO IMPORTANT GROUPS OF LYMPHATIC GLANDS ARE SHOWN, WITH THEIR VASCULAR SUPPLY. ONE OF THEM (G. 1), SUPPLIED BY THE SUPERIOR THORACIC ARTERY, LIES CLOSELY APPLIED TO THE UPPER RIBS AND INTERCOSTAL MUSCLES, BENEATH THE INSERTION OF THE PECTORALIS MINOR MUSCLE (P.MI.) AND THE SUBCLAVIUS (NOT LETTERED). THE OTHER GROUP (G. 2), TRAVERSED BY THE INTERCOSTO-HUMERAL NERVE (I.H.N.) AND SUPPLIED BY BRANCHES OF THE SUBSCAPULAR ARTERY (S.A.) AND BY SPECIAL BRANCHES OF THE AXILLARY ARTERY (A.A.), IS PLACED LOWER DOWN IN THE AXILLA IN FRONT OF THE SUBSCAPULARIS AND LATISSIMUS DORSI (L.D.) MUSCLES. THESE GROUPS OF GLANDS ARE OF MUCH IMPORTANCE IN THE OPERATION FOR CANCER OF THE BREAST. THE PYRAMIDAL SHAPE OF THE AXILLA, NARROWING TO A POINT BENEATH THE SUBCLAVIUS AND CLAVICLE, IS CLEARLY SHOWN. THE PECTORALIS MAJOR (P.MA.) HAS BEEN DIVIDED AND TURNED UPWARDS WITH THE PECTORALIS MINOR. D., DELTOID MUSCLE. B.M., BICEPS. C.B., CORACO-BRACHIALIS, PIERCED BY THE MUSCULO-CUTANEOUS NERVE. A.V., AXILLARY VEIN, IN FRONT OF WHICH IS THE INTERNAL CUTANEOUS NERVE (I.C.N.). M.N., MEDIAN NERVE. U.N., ULNAR NERVE. M.S.N., MUSCULO-SPIRAL NERVE. C.A, ANTERIOR CIRCUMFLEX ARTERY AND VEIN.

enter upon the inner margin of the gland, and communicate freely with the branches coming to its outer border from the axillary artery. The latter vary in exact number and origin, a common arrangement being shown in the figure.

Several branches issuing from the great pectoral muscle pierce the fascia and enter the breast.

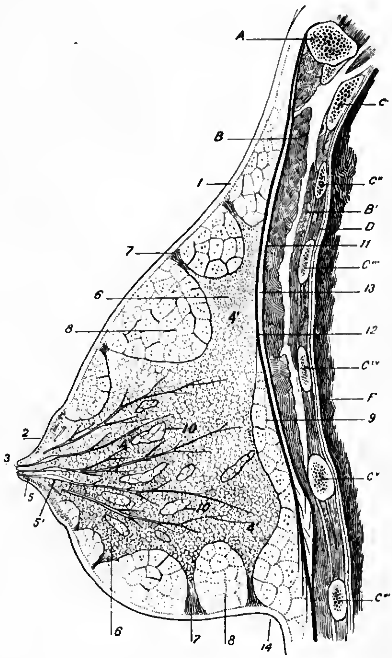

FIG. 309.—VERTICAL SECTION THROUGH THE BREAST. (*From Testut.*)

Extensions of the mammary tissue towards the suspensory ligaments (6, 7, 7) are seen, and the close relation of the breast to the pectoral fascia (11, 12, 13).

A, Clavicle; B, Pectoralis major; C', etc., the first to the sixth ribs, etc. (*See also* text.)

The chief blood supply of the breast comes from the axillary side, but the most difficult vessels to secure are the short perforating branches of the internal mammary.

In clearing the axilla of its contents, several small, unnamed branches of the axillary artery and vein to the lymphatic glands will be divided, as well as branches from the main subscapular vessels. Care should be taken, however, not to injure the latter.

With regard to the *lymphatic vessels of the breast*, the great majority run upwards and backwards into the axilla; some, however, accompany the intercostal arterial branches and enter the anterior mediastinal glands. The latter are of small importance to the surgeon, inasmuch as they derive their lymph from the inner side of the breast, which is rarely the starting-point of cancer. Moreover, in the rare cases of mediastinal glands enlarging from secondary deposit, they are quite inaccessible to the operator.

The Lymphatic Glands of the Axilla.—(*See* Plate XX.). These are of great importance in connection with breast tumours. They vary much in number (from ten to forty in each axilla), in

situation, and in development according to the age of the patient and the active or passive condition of the breast. These variations alone would make the minute subdivision by some anatomists into ten or more exact groups ridiculous, and such an attempt is useless from the clinical point of view. In advanced age the axillary lymphatic glands often become invaded with, and are

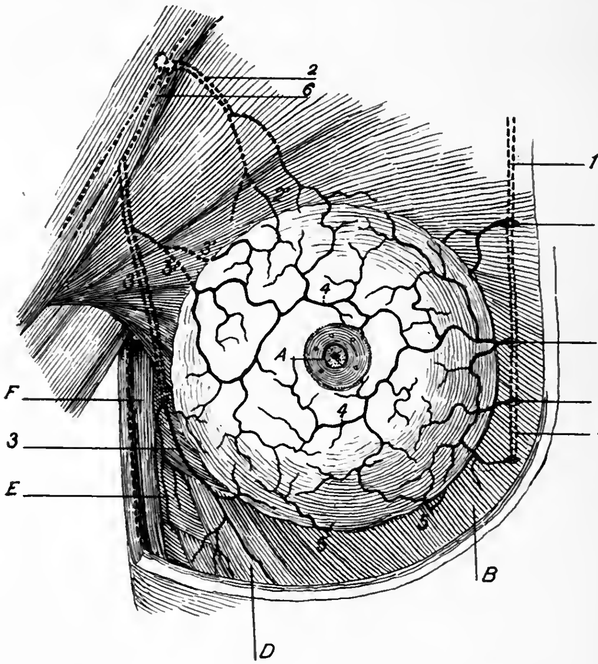

FIG. 310.—ARTERIAL SUPPLY OF THE BREAST. (*From Testut.*)

1, Internal mammary artery; 2, Superior thoracic coming from 6, the axillary; 1', 1'', 1'', Perforating branches from internal mammary; 5 and 5', Others from the intercostal arteries; 3, External mammary from axillary; 4, 4, Anastomotic circle round nipple; A, Nipple; B, Pectoralis major; D, External oblique; E, Serratus magnus.

hardly to be distinguished from, the surrounding fat. As the breast atrophies many of them atrophy too.

In our opinion these glands may be properly arranged into four, or at most five, groups :—

1. The humeral glands (four or five) close to the axillary vein, receiving the arm lymphatics and continued above into the subclavian glands (six to twelve), also close to the vein on its inner and front aspects.

The only reason for separating these two groups, which form one continuous chain, is that the upper glands receive lymph freely from the breast after it has traversed other glands. The humeral glands rarely do so.

2. The thoracic group (four to six) on the serratus magnus muscle. (Plate XX.)
3. The subscapular group (four to eight) along the main artery and vein of this name and its dorsal branch. These glands have little to do with the breast, as a rule, though throughout the axilla communications between the different glands are frequent.
4. The midaxillary group (four to eight) scattered in the axillary space; the lowest of them are near to the skin, others lie under the pectoralis major, and above they join with the subclavian group.

Besides these, a few scattered glands are usually present just behind the pectoralis minor, above this muscle close to the root of the coracoid process, and near the origin of the subscapular artery, or along its course.

The practical deduction from this is that if the pectoralis minor be excised with its fascial investment (the whole suspensory ligament of the axillary), some lymphatic glands will probably be removed with it which would otherwise escape detection.

The lymphatics from the arm, breast, etc., whether they enter the axillary glands or not, ultimately converge into one or two main trunks which join the subclavian vein where it meets the internal jugular, or slightly below this. The supraclavicular glands are quite distinct from the axillary lymphatics, and when they are found to be affected by scirrhus, the process seems to be one of retrograde lymph embolism, such as is seen occasionally in the humeral glands already mentioned. This point is of practical importance, since from it we infer that the glands above the clavicle are outside the range of operation for complete clearance of the breast and its lymphatics. As a matter of fact, we have in no single case known benefit follow removal of the supraclavicular glands when invaded by scirrhus deposits.

The only operation on the breast which requires full discussion

is its excision for malignant growths, but a word or two may be said with regard to **removal of adenomata.** These tumours are always well defined and enclosed in a capsule. The incision for the removal of one should be made right down through this capsule, in a line radiating from the nipple. If the tumour is pushed forwards and the skin stretched by grasping the breast firmly with the left hand, a short incision will suffice for the tumour to project and for the surgeon to shell it out.

In excising cysts of the breast, it is never possible to remove them entire without a margin of healthy mammary tissue. After removal of either cysts or adenomata, silkworm-gut sutures should traverse the greater depth of both wound-surfaces; in other words, they must not be passed merely through the skin, or a cavity will be left which is certain to fill with blood and delay healing. The walls of the cavity must be brought into accurate contact, and the stitches should be left in for six or seven days.

EXCISION OF THE BREAST

Instruments required.—Several large and small scalpels. If one knife is used for cutting into the tumour, it should be at once laid aside and another taken. Dissecting and sharp-pointed forceps; fifteen to twenty Wells' pressure forceps; two pairs of scissors; aneurysm needle (occasionally wanted); vol-sellum forceps; blunt dissector; needles, sutures, and needle-holder, etc.

Position.—The patient is brought to the edge of the table, and lies with the head and shoulders raised. The arm of the affected side is well raised from the side and supported on a small hollow rest attached to the operating-table, so that it is at right angles to the trunk. If this form of support is not available, the arm should be held by an assistant or nurse.

The axilla has been thoroughly shaved and disinfected before-hand. The arm, neck, and abdomen are protected by macin-tosh sheeting, over which sterilised towels are placed. It should not be forgotten that the wound area will be a large one, situated over the lungs, and therefore that the patient is apt to suffer severely from chill during the long operation. Beneath the macintosh or towels every part of the skin surface should be warmly clothed, and the air of the theatre must be of a really

suitable temperature. Finally, just before the operation the skin of the operation area is gone over with alcoholic solution of carbolic acid (1 in 20), or of biniodide of mercury (1 in 500). Sterilised sponges, towels, or pads of dry absorbent wool are packed between the side of the patient's chest and the operating-table to absorb the blood, which tends to run down over her back.

In dealing with either breast, the surgeon, of course, stands between the patient's trunk and arm, whilst the chief assistant

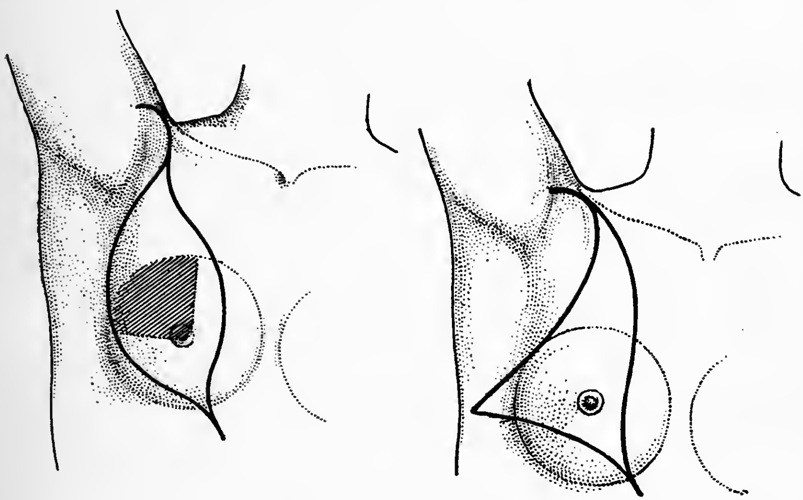

FIG. 311.—INCISIONS FOR REMOVAL OF BREAST AND CONTENTS OF AXILLA, SHOWING MODIFICATIONS ACCORDING TO THE AMOUNT OF SKIN REQUIRED TO BE REMOVED.

In the left figure the shaded area, the upper and outer quadrant of the breast, indicates that part in which scirrhus commences in nearly three out of four cases. In both figures the wound is placed in front of the axilla, and its upper end curves over the pectoralis insertion.

may stand behind the shoulder or on the opposite side of the trunk. He helps to retract the parts, to hold up the breast when required, and to grasp any bleeding point with pressure forceps. A second assistant may stand by the surgeon's side. Both assistants should have pressure forceps close at hand.

Preliminary Incision into the Tumour.—If there is the slightest doubt as to the diagnosis, a short incision should be made into the very centre of the tumour. It has happened to many surgeons to remove a breast containing a cyst or chronic abscess in the full belief that the disease was cancer. The objection to

a preliminary incision—that it may infect the surrounding breast-tissues with cancer cells—is not worth discussing. Of course, the knife used should at once be put aside. It occasionally happens that the incision still leaves the diagnosis in doubt, as there may be one or more cystic spaces with little evidence of true tumour, and sometimes a breaking-down-scirrhus is very like tuberculous mastitis. In such a doubtful case the safest policy will be to excise the whole breast.

The Incision, etc.—The exact incision made will vary according to the individual case, though its general form will be elliptical, the centre of the ellipse being about the nipple. The upper end of the incision used to be made through the centre of the axilla, but it is much better to place it well over the border of the pectoralis major muscle, tailing slightly downwards across the insertion of the latter (*see* Fig. 311). The reasons for this are: 1. The axillary skin is provided with large hair-bulbs and modified sweat-glands. It is practically impossible to render these aseptic, and hence the wound should not be made through this region of skin. 2. In many cases, probably in all, it is best to remove with the breast the costal or lower portion of the great pectoral muscle, and this is rendered easy by this modification of the old incision. 3. Clearing the axilla, especially the upper part of it between the clavicle and the first rib, is done by open dissection through this incision. By the midaxillary one this step was effected mainly by finger traction in the dark, with increased risk of venous hæmorrhage.

When adhesions exist between the skin and tumour, the former must be freely sacrificed, as slight delay in healing of the wound is of no importance compared with the risk of leaving nests of cancer cells behind. In some cases it is advisable to excise a **V**-shaped piece of skin covering the outer part of the breast, as well as that removed by the modified elliptical incision.

In dealing with the right side, the surgeon commences the incision over the axilla and cuts toward the chest.

In dealing with the left breast, it is convenient to commence the incision at its lower part, and cut towards the axilla.

In either case the lower or axillary half of the incision is made first for convenience as to the bleeding. The flap is retracted by

careful dissection until the posterior fold of the axilla (edge of the latissimus dorsi) is reached. Any divided arteries are seized with Wells' forceps. Care should be taken not to button-hole the skin flap in dissecting it back. The assistant has been making upward traction on the breast, i.e. away from the line of the surgeon's incision.

The second incision is now made—that above and to the inner side of the nipple. The exact course will depend entirely on the size, depth and superficial adhesions of the scirrhous tumour (*see* Fig. 311). If the skin is perfectly free from the growth, the wound may just skirt the nipple area, but any adherent skin must be widely avoided.

As the cut is made, the surgeon steadies the breast with his left hand, which is made to press in the direction opposite to that followed by the knife, so as to keep the skin tense.

The knife should at first involve the skin and superficial tissues only, and should just pass down into the subcutaneous fat. As soon as the ellipse has been completed the surgeon should turn to the V-shaped point at each extremity of the wound, and should see that the skin is entirely free at these points. It is very common for the mass to be held here, owing to a faulty division of the skin.

The chief assistant now draws the skin up on the sternal side of the mamma towards the median line, while the surgeon lightly presses the breast downwards with his left hand. While the parts are in this position the upper limb of the incision is carried down to the pectoral muscle. If the skin be fully retracted by the assistant, a division of the deeper parts well beyond the limits of the breast is ensured.

The surgeon now grasps the breast and drags it away from the thorax, while he severs its deep attachments in such a way as to lay bare the great pectoral muscle. The fascia forming the sheath of this muscle should always be removed, and it makes little difference as regards future use of the arm whether the whole thickness of the costal portion be taken or not. As its removal greatly helps a thorough clearance of the axilla, it may be advised in nearly all cases. In dividing the muscle close to its origin from the sternum and costal cartilages the anterior perforating vessels must not be cut too close to

their points of emergence. As a rule they can be secured by pressure forceps before being cut across.

The breast, with the underlying muscle, is now drawn downwards and outwards, and the insertion of the great pectoral divided cautiously so as to expose the axillary vessels, the incision being made at right angles to the fibres. With ordinary care there is no risk of damaging the axillary vein, as a layer of fascia and some fat separate the muscle from it.

Some surgeons recommend that the pectoralis minor should invariably be removed at the same time. This is not necessary, and somewhat increases the severity of the operation. In completing the removal of the breast and axillary contents, the serratus magnus, the subscapularis, the axillary vessels and nerves will be laid bare. It is well to expose the vein early, and the handle of the scalpel or a blunt dissector will be used to detach the chain of lymphatic glands which runs alongside it. Very rarely it may be necessary to excise part of the axillary vein between two ligatures in order to get away adherent glands. This should be avoided, if possible, as the cephalic vein may be deficient, and œdema of the arm is then apt to follow.

The intercosto-humeral nerve, which traverses the centre of the axilla, will often require to be divided. This division causes subsequent numbness at the lower and inner part of the arm. The three subscapular nerves, the corresponding artery and vein, and the long thoracic nerve must be spared. Branches of the subscapular and axillary vessels to the lymphatic glands will necessarily be divided, and all such vessels should, if possible, be clamped before their section.

Careful search should be made for the lymphatic glands which lie close to the coracoid process and first rib, and they should be removed, whether apparently infected or not.

It is now convenient to mention the following *general points* with regard to excision of the breast: 1. All bleeding points should be picked up neatly, and not grabbed up together with a mass of the surrounding tissue. Each vessel should be clamped if possible before its division. 2. The wound should not be scrubbed with a sponge. It barely needs to be sponged at all. 3. Sterilised water should be used to wash the wound. It should be cleansed by washing, and not by sponging. A kidney-

shaped receiver is placed beneath the wound, and a stream of warm sterilised water is allowed to run over the raw surface until all clots have been washed away.

The bleeding points are now dealt with. In the majority of cases the long-continued pressure of the forceps will suffice to close the larger number of the vessels; others are occluded by twisting the pressure forceps before they are removed. But as recurrent hæmorrhage is more common after excision of the breast than any other operation, it is best to tie every doubtful vessel with catgut or fine silk. When this has been done and the cavity flushed with warm sterile water, the long wound is sewn up.

The sutures are of silkworm gut; the upper and lower ones are applied first, the middle ones being left to the last. The sutures are not tied until the upper and lower series are completed. They are then knotted, and the assistant follows the closing wound with sponges, so applied as to maintain considerable pressure over the recently united incision, and to obliterate the wound cavity. This pressure must not be relaxed. In a few cases an opening for a drainage-tube is now made in the hollow of the skin below the wound. A tube is inserted and secured by a suture. The drainage-tube may be dispensed with, and it appears to increase slightly the risk of suppuration. Nevertheless we advise the use of the tube in the majority of cases; if it is omitted, oozing of blood into the cavity is somewhat apt to occur, producing a troublesome complication. The tube should be of small calibre, may well be a spiral one, and should be removed within three days. We analysed 50 cases treated at the London Hospital with drainage, and fifty without. Perfect healing of the wound was more constant in the latter series, but there is a possible fallacy involved in that the worse cases on the whole may have been drained.

The middle sutures—i.e. those in the central part of the wound—are now inserted, and when they are all in place, tied. The assistant with the sponges still follows the sutured incision, and obliterates by pressure the wound cavity. The dressing is prepared. It consists of a large pad of sterilised gauze or dry cyanide gauze, over which sterilised wool is used. The wool covers the whole side of the chest, the opposite breast, the

shoulder, and the back as far as the spine. A point of some practical importance is to have the voluminous dressing of wool and gauze ready prepared to apply immediately the sponge pressure is removed from the wound.

Until recently it was the custom, after excision of the breast, to bandage the arm of the same side against the chest wall—making, in fact, a splint of it—to keep the dressings at rest. It was usual to maintain the patient's arm in this position for ten days or so, allowing movement neither at shoulder nor at elbow-joint, and sometimes even confining the fingers and hand closely against the thorax. Such confinement is, of course, irksome to the patient, and apt to be followed by stiffness of the joints, which is but slowly recovered from. The axillary vein may become adherent to the side of the chest, and circulation be thereby impeded. Moreover, keeping the arm pressed against the side of the chest encourages axillary perspiration, and may thus favour infection of the wound. As long as the shoulder-joint is kept at rest, freedom of the elbow and hand cannot interfere in the least with healing of the wound. The best way is to envelop the axillary and pectoral region with a large dressing, which is kept securely in place by a figure-of-eight bandage applied whilst the assistant supports the arm at about a right angle from the chest wall. The arm is subsequently supported on a pillow at a rather smaller angle. Especially in warm weather, a white bandage is preferable to a flannel one.

After-Treatment.—If there be any pain, a hypodermic of morphia may be given on the evening of the operation-day, but this is rarely required. As a rule, the patient complains chiefly of back-pain, and this may be relieved by changing the posture from time to time.

The dressing should be left undisturbed for ten to fourteen days, if possible. When the wound is exposed the greatest care should be taken as to asepsis, and the removal of the stitches and change of dressing should be effected with sterilised instruments rather than the fingers, and with a complete avoidance of flushing or free "swabbing" of the wound. The manipulations, in a word, should be dry.

If a drainage-tube has been inserted, it should be withdrawn at the end of two days without disturbing the whole of the

dressing. This is easily effected if a suture has been passed through the free end of the tube (not the skin) and left long and dependent.

Comments upon the Operation and Modifications of the Procedure.—In dealing with large tumours, such as some sarcomata, the skin incision must be planned with much care, or the operator will fail to adjust the margins of the wound. If much tension fall upon the sutures at one part of the wound in consequence of an unusual amount of skin having been removed, it is best not to attempt to bring the edges together at this part. After an aseptic dressing has been applied for a week, the raw surface will be found in a good condition for grafting, though this is often unnecessary. The grafting by Thiersch's method may be done at the time of the original excision, but it is probably better to wait a week or more, and the grafts can then be taken without other anæsthetic than cocain or eucain being required.

It appears to be totally unnecessary in ordinary cases of malignant disease to remove the *whole* of the skin covering the breast, whether sound or unsound, as some advise. Such skin as is implicated by the disease or adherent thereto must, of course, be freely removed; but if the disease be so advanced that all the integument covering the mamma is involved, then it is probable that the case is not suited for treatment by operation.

Should the Operation always include Clearing the Axilla?—In no case of scirrhus of the breast is it wise to leave the corresponding axillary glands, since microscopic examination proves that secondary deposits are present in the latter in at least three out of four cases at the time of operation.*

It is often quite impossible to detect the earliest infected glands by palpation; indeed, it may require thorough search in the excised contents of the axilla to find them. Glands completely converted into scirrhus and yet no larger than grains of wheat are often found at the time of operation. The presence of a microscopic deposit of cancer cells in one axillary gland may render the excision of the breast alone of no real

* McWilliams (*Med. News*, April 28, 1900), 78 per cent. The results of many other observers are to the same effect.

value to the patient. Hence, although the immediate risk of the operation is somewhat increased, excision of a cancerous breast should always include excision of the axillary lymphatic glands. If the supraclavicular glands are suspected, they also should be removed, through an additional incision made parallel to and above the clavicle. It must be admitted that when the supraclavicular glands are infected the operation is hardly worth doing. (*See* p. 321.)

Small innocent tumours of the breast are removed through a simple incision, which should follow a line radiating from the nipple. If much thickness of mammary tissue is cut through, a drainage-tube should always be retained for twenty-four or thirty-six hours.

It is sometimes possible to remove an innocent growth by an incision which follows the crease between the lower segment of the mamma and the thorax. Excellent drainage is provided by such an incision, and the scar is entirely hidden from view. Usually this method is impracticable without an awkward dissection.

Results of Excision of the Breast.—The actual mortality following the operation of excision of the breast is very low, and is at the present day probably less than three per cent.

The prospect of a cure following the operation has undoubtedly been much increased during the last twenty years, since Moore, Mitchell Banks, Watson Cheyne, and others have taught the vigorous and thorough extirpation of the cancerous breast and all axillary glands in every case suitable for operation. Some have placed the percentage of those who remain free from recurrence as high as 60 or 70 per cent., but this very favourable result is only arrived at by fixing an arbitrary time-limit of three years or so. *There is no such time-limit for the recurrence of cancer.* It may take place ten years or more after an apparently successful operation. However, a proportion of even 40 per cent. of cures by operation in cases of mammary scirrhus is much better than could have been anticipated twenty years ago.

Operation on Recurrent Growths. — When recurrence is met with in the skin or subcutaneous tissue of the chest-wall, it should certainly be operated on, except in the rare cases of

widespread and rapid infiltration, suggesting erysipelas. These last are wholly unsuitable for any further surgical interference. The fact that one or two nodules show themselves a year or two after the major operation is rather an indication that a few outlying cells of the growth have been left behind than that the patient is the hopeless victim of a general cancerous tendency. Even repeated excisions of local recurrent growths occasionally result in permanent cures. Sometimes the recurrence takes place in the remaining breast, and, if the conditions are favourable, a second excision may result in a permanent cure. Of this unexpected result Mr. T. Bryant and others have recorded many examples. When the recurrence is so extensive that excision is not worth doing, the operation of double oöphorectomy may be performed, as advocated by Dr. Herman and Mr. Stanley Boyd. It was first suggested as a remedial measure in cancer by Dr. Beatson of Glasgow, and has only been tried since 1899. The following provisional conclusions may be drawn from Mr. Boyd's collected series of cases and from others under our own observation :—

1. Oöphorectomy in some cases has apparently a definite effect in checking the growth of cancerous tumours ; in others it fails entirely.
2. The most suitable cases are those in which the patient is approaching the menopause.
3. It is rarely worth doing if the patient is elderly—i.e. over fifty years of age.
4. It is occasionally followed by considerable shock, and should only be resorted to if the patient's age is favourable to the chance of benefit resulting from it.

Our colleague Mr. Hugh Lett (*Med.-Chir. Trans.*, 1907) has published a careful analysis of cases treated by oöphorectomy. On the whole the measure has proved to be very disappointing in its results.

PART V.—OPERATIONS ON ARTERIES, VEINS AND NERVES

CHAPTER I

THE LIGATURE: GENERAL CONSIDERATIONS

History of the Ligature.—The use of the ligature as a hæmostatic dates from the very earliest times.

It was advised by Celsus, who flourished in the first century. "The bleeding vessels," he wrote, "are to be taken up, and two ligatures to be applied, one on each side of the wound, and then to be divided between the ligatures." The proceeding, however, was not generally adopted, and to Ambrose Paré is certainly due the credit of introducing the ligature definitely into surgical practice.

So novel was Paré's proposal that, although he was familiar with the use of the ligature as described by the ancients, he regarded his invention as quite phenomenal. "I think it was taught me," he writes, "by the special favour of the Sacred Deity; for I learnt it not of my masters, nor of any other, neither have I at any time found it used by any." This was in the year 1564. This very important element in practical surgery was very slowly accepted. The great English surgeon Wiseman, writing more than one hundred years later, recommended the use of a "royal" styptic, or the cautery, in the place of the ligature.

Sharp, writing in 1761, takes pains especially to advocate the use of the ligature for the arrest of bleeding, because "it was not as yet universally practised among surgeons residing in the more distant counties (of England)."

Antyllus, who flourished in the fourth century, is reputed to have treated aneurysm by first ligaturing the artery above and below the tumour, and then evacuating the contents of the sac. He was careful to isolate the vein, and passed the thread by means of a needle directed by a probe.

Anel ligatured the brachial artery in 1710, for a traumatic aneurysm at the bend of the elbow, applying the thread close to the tumour. In December, 1785, John Hunter, after many experiments

and careful investigation of the whole subject, ligatured the femoral artery, in what is now known as Hunter's canal, for the cure of popliteal aneurysm.

From this time dates the modern method of treating aneurysm by ligature.

The introduction of catgut as a ligature material, by Lord Lister, and the employment of antiseptic measures in the treatment of wounds, have greatly modified the dangers of the operation.

The silk ligature was left in place until it had cut through the vessel. Its extremity was allowed to hang out of the wound. It acted as a seton. Primary healing was not possible; and secondary hæmorrhage, and the evils attending suppuration, were quite common.

The use of *animal ligatures*, which could be absorbed in due course, and which would introduce no septic matter into the wound, altered the aspect of the operation. The animal ligature appears to have been first introduced in 1814, by Dr. Physick, of Philadelphia. He used little strips of chamois leather which had been rolled upon a slab until they were hard and round. The ligature was cut short, and was never seen again in those wounds which healed by first intention. These ligatures appear to have been employed in the United Kingdom, together with other experimental forms of animal ligature. Sir Astley Cooper tied the femoral successfully with catgut, while Dr. McSweeny, of Cork, recommended silkworm gut. Silk was, however, the regular material employed until Lister definitely introduced catgut and established the properties and determined the preparation of that substance.

The materials more recently introduced are ligatures of ox aorta and of kangaroo tendon. The former has been used but seldom, and may be said to have passed into oblivion. Kangaroo tendon, however, has come into wide favour. It is (bulk for bulk) stronger than prepared catgut, may be had of any thickness, and can be preserved in an aseptic condition for any length of time. Mr. Clinton Dent (*Med.-Chir. Trans.*, vol. lxiv.) has well described and figured the histological changes occurring in tendon ligature and in the artery that is tied with it.

Instruments required. — The following is the list: 1, scalpel; 2, two pairs of fine toothed forceps; 3, small blunt hooks; 4, retractors; 5, long toothed forceps; 6, pressure forceps; 7, aneurysm needle; 8, ligature; 9, a blunt-pointed dissector.

1. The scalpel should be small, and of the pattern already

described. A stout instrument may be used for the skin incision, a finer for opening the sheath.

2. The tissues are often very conveniently divided between two pairs of forceps, one pair being held by an assistant.

3. Small blunt hooks, with long shafts, are most convenient as retractors, especially to draw nerves and tendons out of the way. Their use is well illustrated in the operation for securing the lingual artery.

4. Good retractors are needed when deeply-seated vessels are concerned. In securing the iliac arteries, for example, large rectangular retractors are of use.

5. The sheath should be picked up by the toothed forceps.

Specially long forceps are needed for securing the iliac arteries.

6. As the wound must be as bloodless as possible, pressure forceps are very necessary. If the bleeding vessel be carefully picked up, and the forceps be allowed to remain long attached, the hæmorrhage will usually be checked without the need of a ligature.

7. The aneurysm needle must be well made and well polished. It need not be too fine. In dealing with large and deeply-placed arteries a strong needle is required. Needles are not infrequently met with made of such indifferent metal that they bend under a not unreasonable strain.

8. There is considerable choice in the form of ligature used, the most essential points being (*a*) that it should be strong enough without being cumbrous or too rigid (if chromicised catgut be used it may cut through the wall of an artery or vein like wire), (*b*) that it should be resistant enough to last as a firm knot for at least ten days or so, and (*c*) that it should be perfectly aseptic when introduced into the tissues.

Kangaroo tendon, catgut, and soft silk of medium thickness may all be recommended. Whichever is employed, it should have been kept in alcohol and not in an oily medium.

The ligature to be applied should always be selected with great care and well tested.

It should be allowed to soak for ten minutes or so in sterilised water, and should then be again examined and tested. It must be long enough to be easily manipulated. Many surgeons prefer

a ligature of kangaroo tendon to one of catgut, on the ground that the latter material is not always of thoroughly reliable composition. If silk be used, it should have been boiled immediately before the operation, and should be handed with sterilised forceps to the operator.

In these operations absolute asepticism is vital.

9. In the exposure of deeply-placed vessels a good light in the depths of the wound is essential. This may be obtained by means of a reflector, or, better still, by the use of an electric head-lamp.

Position of the Patient.—The position of the patient will vary a little according to the artery to be tied. In general terms, it may be said that the surgeon should stand upon the side to be operated on, and that the incision on the right side is more conveniently made from above downwards, and on the left side from below upwards. The chief assistant stands opposite to the surgeon, and has for his principal duty the sponging and the retraction of the parts of the wound.

The Steps of the Operation.—These will be considered in the following order :—

1. The line of the artery.
2. The incision.
3. The exposure of the artery.
4. The opening of the sheath.
5. The passing of the ligature.

1. *The Line of the Artery.*—This line must be very accurately defined. It may differ from what is commonly given as the anatomical line of the vessel.

For example, the course of the ulnar artery is said to be represented by a line drawn from the middle of the bend of the elbow to the radial side of the pisiform bone. This line scarcely touches the artery, however, at any one point. The surgical line for the lower two-thirds of the vessel—the part upon which a ligature may be applied—is represented by a line drawn from the tip of the internal condyle to the radial side of the pisiform.

The posture of the limb, also, is of moment. In indicating the exact situation of the femoral or brachial arteries, for instance, it is essential that the limb should be placed in a certain position before the line is drawn.

The size of the artery should be realised. In the sections which follow, the dimensions—as given by Quain—are noted in connection with each vessel.

The operator should also be aware of the possible variations of the artery to be exposed.

2. *The Incision.*—The incision should, when possible, be so placed upon the line of the artery as to avoid superficial veins. It is most desirable that there should be little bleeding during the operation, that the wound should be "dry," and the view of the depths not embarrassed by pressure forceps.

The scalpel should be held in what is termed the dinner-knife position (Fig. 312). The cut should be freely and cleanly made. There is a disposition to make the wound too small. A small wound carries with it special dangers and difficulties, whereas a little increase in the length of the skin-cut does not add to the gravity of the procedure.

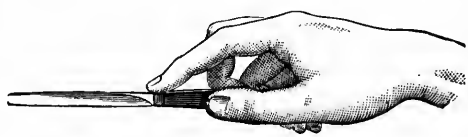

FIG. 312.—THE "DINNER-KNIFE" POSITION.

The knife should be entered at right angles to the surface, and should be in the same position when withdrawn. The surface wound should be of equal depth throughout. There should be no "tails" to the cut.

The skin should be steadied with the left hand while the integuments are being divided.

After the surface cut has been made, the next step is to divide the deep fascia, or aponeurosis. This is done by a clean cut made in the line of the original incision and carried the whole length of the wound.

A director is not required either at this or any other stage of the operation. In the ligature of arteries the director should be avoided as an unnecessary and dangerous weapon.

When the deep fascia has been exposed in a limb, the outlines of the underlying muscles and tendons are rendered more or less distinct. A gap between two adjacent muscles has usually to be followed in the operation. This gap is commonly said to be indicated by a white or a yellow line.

Neither of these can be relied upon.

The interval is best sought by the sense of touch and by the left index finger. A highly educated left index finger is the most valuable factor in the performance of any operation for the ligation of an artery.

The space is to be felt when it cannot be seen, and the artery itself is often more surely to be recognised by the finger than by the eye.

The muscular interspace is best opened with the handle of the scalpel or with the finger. No attempt should be made to demonstrate it with the edge of the scalpel. Dissection is here out of place. The narrow and obscure tract of connective tissue that leads down to the artery is better followed by the sensitive finger than by any sharp instrument.

In opening up the depth of the wound the posture of the limb may be so altered as to relax the muscles about the incision. It is better that this should not be done until the interspace has been well and clearly demonstrated.

The deep part of the wound should follow the line of the superficial incision, and should equal it in extent. The wound should not be funnel-shaped.

Retractors must be freely used. Every means must be adopted to expose the depths of the wound clearly. All bleeding must be checked as it is encountered. The wound should be kept dry to its very bottom. In effecting this end the part can often be so inclined that blood tends to flow from the wound by gravitation rather than into it.

Above all things, the operation must be conducted step by step. Each guiding point must be well made out before the next point is sought for. This circumstance is well illustrated by the operation for securing the lingual artery.

3. *The Exposure of the Artery.*—The artery should be sought for with the finger. As the tissues will be more or less evenly stained with blood, the finger—in a deep wound especially—affords the best means of differentiating the artery, the veins, and a companion nerve.

To the touch the nerves feel firm, resisting, round, and cord-like. They cannot be flattened by the pressure of the finger. The veins greatly exceed the corresponding arteries in size. They often overlap these vessels. They feel soft and yielding, and thin-walled. They are easily compressed, and when so treated swell out upon the distal side. When the finger touches the compressed vein the vessel as a tube can scarcely be appreciated. In this respect it is very different from the artery. The artery feels firmer and more elastic. It is not unlike a thin indiarubber tube to the touch. It is movable, and often slips about under the finger in a characteristic manner. It can be compressed, but not so readily as the vein. When flattened out by the finger, an artery of moderate dimensions feels like a flat band or

thong, thick and elastic, and hollowed out a little in the centre, so that the margins feel thicker than the median part. Above all, it pulsates.

There are many fallacies in this. The pulsations of the artery may be transmitted to the nerve (as in the case of the median nerve and the brachial) or to the companion vein. When the patient is under an anæsthetic, and when the pulse is feeble, or very rapid, the movement in the artery may be difficult to detect. If an aneurysm or pulsating growth exist, compression of the artery causes the pulsation in the tumour to cease.

The artery when exposed is often found much contracted. It looks so much smaller than was expected that it may, in such case, be mistaken for an abnormal vessel.

In the matter of the appearance of the tissues, the depth of the wound—which is often great—and the even tinting of the parts with blood render an inspection of less value than an examination with the finger. When the wound is well opened up the nerves stand out as clear, rounded, white cords; the veins are of a purple colour, and of somewhat uneven and wavy contour; the artery is regular in outline, and is of a pale pink or pinkish-yellow tint, the large vessels being of lighter colour than the small.

There may be one companion vein or two—the *venæ comites.* All arteries below the knee are accompanied by venæ comites. All arteries of the arm, forearm, and hand are attended in like manner.

The arteries of the trunk which are of small or of medium size are for the most part accompanied by venæ comites; such are the pudic, the deep epigastric, the deep circumflex iliac, and the internal mammary.

The arteries in the head and neck are attended by single veins, the only noteworthy exception to this being the lingual artery.

The venæ comites lie close to the artery, one upon each side of it. They are apt to communicate with one another freely across the vessel by means of many transverse branches. When the artery is placed between muscles which lie the one in front of the other—as is the case with the posterior tibial artery—the companion veins lie one on each side of the single trunk. When, however, the muscular interspace is antero-posterior, as is the gap between the tibialis anticus and the extensor communis digitorum, in which the anterior tibial artery lies, the veins are so placed that one is in front of the artery and the other behind it.

4. *The Opening of the Sheath.*—The artery is now reached. It remains to open the sheath, and to clear a part of the vessel for the passage of the aneurysm needle.

The sheath must be opened with the scalpel with infinite care and the most delicate precision. The knife must have a perfect cutting edge. A good light is essential, as is a pair of trustworthy forceps, by means of which it is possible to pick up a fine fold of tissue and hold it firmly.

The sheath is picked up over the *centre*, or median part, of the artery, in the form of a fold which is *transverse* to the long axis of the vessel. It must be picked up cleanly and entirely. It is unwise to pick up a longitudinal fold. In the first place, such a fold is not so easily grasped nor so readily raised from the vessel, and, in the second place, the forceps may catch up at the same time a longitudinal fold of the subjacent arterial coat, or even of one of the veins.

The transverse fold of the sheath is then incised. The cut should be clean, should be made in the *long axis* of the artery, and over the *centre* of the vessel. In length it should be from 5 to 10 mm.

When the sheath has been well divided, the serous-like space between it and the artery becomes at once evident.

Before the incision is made, the point of the forceps may be moved a little to and fro, to ensure the freedom of the part which is held from any deep attachments. The sheath may in this way be readily identified.

The blade of the scalpel should be inclined obliquely, i.e. with the flat of the knife towards the artery.

The fold of the sheath must be held well up during the making of the incision. When once a good hold of the sheath has been obtained by the forceps the instrument must not be shifted.

In this part of the operation a director is not only useless but dangerous. The opening of the sheath with a blunt instrument is a proceeding which does not belong to the surgery of the present age.

The method of picking up the sheath with two pairs of forceps (one of which is held by an assistant), and then of cutting between the two blades, is cumbrous, inconvenient, and not without danger.

5. *The Passing of the Ligature.*—The original hold of the forceps upon the sheath should not be relaxed. The surgeon clears a way for the aneurysm needle with the blunt dissector. He then takes the aneurysm needle in his right hand and introduces its unthreaded point between the artery and the sheath for the purpose of clearing the former. The needle should be held with its concavity towards the vessel, and it should be gently insinuated about halfway round the artery, being passed under that part of the sheath held up by the forceps.

The sheath upon the opposite side of the incision should now be taken up with the forceps, and the needle be passed beneath the vessel so as to clear the remaining portion—the deep part—of its surface. The needle will soon emerge in the wound upon the opposite side of the artery, when it should be threaded, and be then withdrawn, carrying the ligature with it.

About one centimetre of the artery, more or less, is cleared. The needle should be kept throughout at right angles to the line of the vessel. It should never be passed threaded.

It is the usual practice to pass the needle from the vein. A more important rule is to pass the needle from the forceps.

It is often more convenient to pass it towards the vein. If the sheath has been well opened, and a way for the ligature carefully cleared around the artery, there can be little excuse for forcing the point of the needle through the sheath into the companion vessel. The aneurysm needle must, of course, be really blunt-pointed.

If a *large vein be wounded*, the practice advised by Mr. Jacobson in the case of wound of the femoral vein during the ligaturing of the artery should be carried out. "The surgeon must not persist in his attempt to tie the artery at the spot, a course which will only end in his inflicting more injury on the vein; but, finger-pressure being made on the lower angle of the wound, the artery is tied either above or below the spot where the vein has been injured. As soon as the artery is secured no further hæmorrhage will take place, but pressure may be kept up by means of a carbolised sponge over the wound for a day or two." A small puncture in a large vein may usually be safely closed by picking up the wounded part of the wall and passing a fine catgut ligature around it, as one would tie up a hole in a bag.

When venæ comites attend a deep artery of moderate size, such as the ulnar or posterior tibial, much time may be wasted and damage done by a determined attempt to separate the artery from the veins. This is especially the case when many transverse connecting branches pass across the artery. In such instances practice has shown that no evil results from including the two veins in the ligature. In dealing with still smaller arteries, such as the lingual, no attempt is made to avoid including the companion veins in the ligature.

It is needless to say that the greatest care must be taken to avoid including a nerve in the ligature. If the sheath be well opened, and the needle be kept close to the artery and be passed round with ease, there is little danger of including a nerve.

If catgut or kangaroo tendon be used, they should have been

rendered pliable by a short immersion in sterilised water of a lower temperature than blood-heat.

The ligature should be passed and be tied exactly at right angles to the line of the artery. The knot should be tied quietly and slowly, and not with a vicious jerk.

It should be sufficiently tight to rupture the inner coats. Care should be taken that the vessel is not dragged out of place in the tying.

The points of the two forefingers should meet upon the artery as the knot is being tied, and the final strain upon the ligature should be given by placing the terminal knuckles of these two fingers in contact and using them as the fulcrum of a lever.

Messrs. Ballance and Edmunds have shown (*Med.-Chir. Trans.*, vol. lxix.) that it is not strictly necessary for success in obliterating arteries to divide the inner coats.

The *knot* should be a reef-knot (Fig. 21, Vol. I., page 54), not a "granny." The double-hitch or surgical knot is not suitable, more especially when catgut is employed. With this material it may be found to be impossible or very difficult to tighten the knot about the artery. Moreover, the knot when made with catgut forms a considerable mass, and is at the best a clumsy method of occluding the vessel.

The reef-knot, if well tied, will not fail.

The practice of applying a *double ligature* to the artery, and of dividing the vessel between them, has been revived from time to time since Celsus advised it. Abernethy reintroduced the practice in 1797, and was strongly in favour of it, as also were Sédillot, Mannoir, Cline, and others. Secondary hæmorrhage was observed to be much less common after amputation than it was after the application of a ligature for aneurysm, and it was believed that, by applying a double ligature and dividing the vessel between, this tendency would be lessened.

In the case of any large vessel, however, we do not recommend this course. In several cases a fatal result has been due to slipping of the ligature on the proximal end. In one this occurred some hours after double ligature and division of the subclavian. The hæmorrhage was of such a nature that the patient was dead in a few minutes.

After-Treatment.—The superficial wound is closed by sutures, and dressed in the usual way. No drain is required.

In the case of the main artery of one of the extremities, the limb should be kept absolutely at rest and be a little raised. The arm

would lie outstretched upon a pillow, the lower limb would be raised upon an inclined plane. The whole extremity is enveloped in cotton-wool, and is kept warm by hot bottles. In the case of the ligature of vessels of the size of the iliacs, the subclavian, or the common femoral, absolute rest should be enforced for a period of not less than twenty-one days.

The time involved in the after-treatment of cases in which smaller vessels have been ligatured may be regulated in proportion. The period of compulsory rest should be longer in old subjects than in the young, and in cases in which the lower limb is concerned than in the upper.

CHAPTER II

LIGATURE OF THE ARTERIES OF THE UPPER LIMB

THE RADIAL ARTERY

Anatomy.—The radial artery continues the line of the brachial, and, although it is smaller than the ulnar, must be regarded morphologically as the main artery of the forearm. The relations of that part of the vessel only which lies in the forearm will here be considered. (For the anatomy of the artery in the "tabatière anatomique," *see* page 347.) The radial follows a nearly straight course from the bifurcation of the brachial artery—opposite the neck of the radius—to the inner side of the styloid process of that bone. The upper half of the artery is covered by the muscular mass of the supinator longus, the lower half by the skin and fascia only. The supinator longus muscle becomes tendinous about the middle of the forearm. The vessel has behind it, in order from above downwards, the biceps tendon, supinator brevis, insertion of pronator teres, radial origin of flexor sublimis, flexor longus pollicis, pronator quadratus, and the lower end of the radius.

Venæ comites—connected by many transverse branches—accompany the artery, one lying upon each side of the vessel.

The radial nerve is only in direct relation with the artery in the middle third of the forearm. It here lies to its outer side. In the upper third of the limb the nerve is at a considerable distance from the artery, while some three inches above the wrist it leaves the vessel altogether to pass beneath the supinator longus tendon to the back of the hand.

Line of the Artery.—A line from the centre of the bend of the elbow to the gap between the scaphoid bone and the tendons of the extensor ossis and extensor primi internodii pollicis.

Indications.—The arteries of the forearm—radial and ulnar—are not frequently ligatured; the circumstances which usually call for ligature are wound and traumatic aneurysm.

Position.—The surgeon stands upon the side to be operated on. The limb is in the position of supination, and is firmly held by an assistant, who grasps it by the hand and by the upper arm. The

incision on the right side should be made from above downwards; on the left side it is conveniently made in the opposite direction.

1. **Ligature in the Lower Third of the Forearm.** *Operation.*—An incision about one inch and a quarter in length is made over the line of the pulse, midway between and parallel with the tendons of the supinator longus and flexor carpi radialis muscles. The cut must not reach below the level of the tuberosity of the scaphoid (Fig. 314). The commencement of the superficial radial vein usually lies over the artery in this situation, and immediately under the skin. It should be avoided. The fascia, which is here quite thin, is divided in the line of the original wound. The gap between the two tendons is now made manifest. Over or in close relation to the artery may be observed the terminal part of the anterior division of the external cutaneous nerve.

It may be impossible to separate the venæ comites from the artery to a sufficient extent to allow the needle to pass. In such case the ligature must include the veins as well as the artery (Fig. 313).

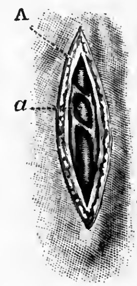

FIG. 313.—LIGATURE OF THE RIGHT RADIAL AT THE WRIST.
A, Fascia; *a*, Artery.

Comment.—The operation is extremely easy. Some confusion may arise in cases where the superficialis volæ artery has a high origin, and lies upon, or by the side of, the radial. This is especially the case when the branch is of unusual size. The radial artery is occasionally absent from its normal situation in front of the wrist, its place being then taken by an enlarged comes nervi mediani artery.

It is said that the synovial sheath of the flexor carpi radialis tendon has been accidentally opened in this operation.

2. **Ligature in the Middle Third of the Forearm.** *Operation.*—An incision two inches in length is made in the line of the artery, the limb being in the position indicated. The centre of the incision corresponds to the centre of the forearm (Fig. 314). In cutting through the subcutaneous tissues care must be taken to avoid any superficial vein belonging to the radial or median veins. The anterior division of the musculo-cutaneous nerve lies usually in the line of the artery, outside the deep fascia and just beneath the superficial veins.

The deep fascia is laid bare and is divided in the length of the original wound. The fibres are transverse (Fig. 315). The supinator longus muscle is now exposed about the point where it is beginning to

become tendinous. The inner or ulnar border of the muscle is defined and the muscle itself is drawn outwards. The elbow may be a little flexed to allow of this being done more easily. The vessel is now found lying upon the insertion of the pronator radii teres, with which it is connected by much connective tissue. The nerve may or may not be seen (Fig. 315).

FIG. 314.—LIGATURE OF THE RADIAL AND ULNAR ARTERIES, AND OF THE BRACHIAL AT THE BEND OF THE ELBOW.

The venæ comites should be separated as well as is possible, and the needle passed from whichever side is the more convenient.

Comment.—As the supinator longus is not very wide at this part (especially if the artery be sought for at the lower end of the middle third), it is very easy to expose the outer instead of the inner border of the muscle, in which case the muscle is apt to be drawn inwards, and when the depths of the wound are opened up the radial nerve is reached. This is the common error of beginners.

The tendon of the supinator longus as a rule first makes its appearance at the outer border of the muscle, so that if this tendinous edge be exposed the operator will know that he has laid bare the wrong side of the muscle. The inner border of the supinator remains muscular until it ends somewhat abruptly in the tendon.

3. **Ligature in the Upper Third of the Forearm.** *Operation.*—This operation differs very little from the last. The incision is two and a half inches in length, and is made in the line of the artery. The centre of the skin-cut corresponds with the part of the vessel to be tied. The radial or other surface vein may be encountered in the superficial part of the wound. After the deep fascia has been divided, the interval between the supinator longus and pronator teres muscles is opened up. There is no difficulty in identifying these two structures: the fibres of the supinator are vertical; those of the pronator are oblique. In muscular subjects the supinator is so wide that its inner border cannot be readily exposed.

Under cover of the supinator the radial artery will be found. The nerve is not in relation with it. The needle should be passed from whichever side is the more convenient.

4. **Ligature of the Radial in the Tabatière Anatomique.** *Anatomy.*—The tabatière anatomique is a triangular space bounded on one side by the extensor ossis metacarpi pollicis and extensor primi internodii, and on the other side by the extensor secundi internodii pollicis. The base is represented by the lower edge of the posterior annular ligament. In the floor of the space are the trapezium, with a part of the scaphoid and of the base of the first metacarpal bone. The radial artery runs over the external lateral ligament of the wrist, just below the styloid process, passes under the extensors of the

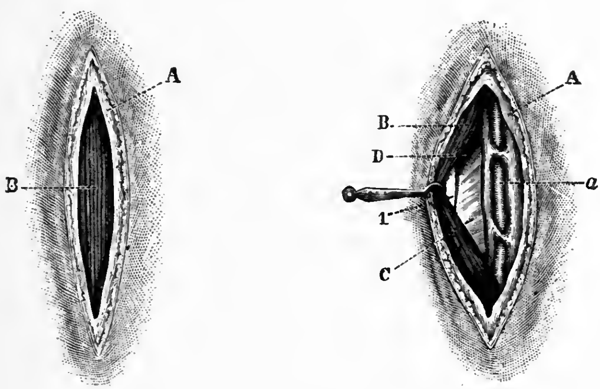

FIG. 315.—LIGATURE OF THE RIGHT RADIAL, ABOUT THE MIDDLE THIRD OF THE FOREARM.

Superficial Wound.—A, Fascia; B, Sup. long.

Deep Wound.—A, Fascia; B, Sup. long.; C, Insertion of pron. teres; D, Sup. brevis; *a*, Artery; 1, Radial nerve.

metacarpal bone and first phalanx of the thumb, and crosses the tabatière. Its course is here represented by a line drawn from the apex of the styloid process of the radius to the posterior angle of the first interosseous space.

The cephalic vein of the thumb crosses the space posteriorly, as does also the internal division of the terminal branch of the radial nerve. A branch of the anterior division of the external cutaneous nerve accompanies the artery, which gives off, while in the upper part of the space, the posterior carpal and first interosseous branches.

Operation.—This procedure belongs mainly to that series of dissecting-room operations which are of value as demonstrating anatomical knowledge. We happen to have had occasion to perform it twice

on the living subject, in both cases for aneurysm. The hand is placed upon its ulnar border, and is firmly fixed there by an assistant, who at the same time holds the thumb extended and abducted and the fingers straight. An incision, about one inch in length, is made along the centre of the tabatière, parallel to the extensor of the metacarpal bone of the thumb, and so placed as to commence at the level of the radial styloid process and lie midway between the extensor ossis and the extensor of the second phalanx of the thumb. The incision will cross the artery a little obliquely. The cephalic vein of the thumb must be avoided. The artery is ligatured in the middle of its course. It will probably be impossible to separate the venæ comites.

It is said that in performing this operation carelessly the synovial sheaths of the adjacent tendons have been opened up, or the joint between the scaphoid and the trapezium has been exposed.

For the variations in the radial artery, *see* page 352.

THE ULNAR ARTERY

Anatomy.—This, the largest artery of the forearm, follows a curved course in the upper third of the limb. It is perfectly straight in direction in the lower two-thirds.

In the first half of its course in the forearm it is deeply placed beneath the superficial flexors, viz. the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor sublimis. From about the middle of the forearm to a point within one inch of the wrist, the vessel is overlapped by the flexor carpi ulnaris. For the last inch of its course in the forearm it is superficial, and is covered only by the integuments and the fascia. The vessel lies at first upon the insertion of the brachialis anticus, and then for the rest of its course in the forearm upon the flexor profundus.

Venæ comites, united by many cross branches, accompany the vessel.

The ulnar nerve comes in contact with the artery at a point a little above the middle of the forearm. Throughout the lower half of the forearm the two are close together, the nerve lying to the inner side of the artery.

Line of the Artery.—The ulnar in the lower two-thirds of its course in the forearm is represented by a line drawn from the tip of the internal condyle of the humerus to the radial side of the pisiform bone. The curve of the vessel in the upper third of its course is such that a line drawn from the commencement of the artery—at the middle of the bend of the elbow—to the radial side of the pisiform bone will scarcely touch the vessel in any part of its course.

The upper third of the artery is too deeply placed to be exposed for ligature, unless it be actually laid bare in a wound.

Indications.—These have been already alluded to (page 344). The artery is secured only in the lower two-thirds of the limb.

Position.—As for ligature of the radial artery in the forearm.

1. **Ligature in the Lower Third of the Forearm.** *Operation.* — An incision, two inches in length, is made along the line of the artery, just to the radial side of the flexor carpi ulnaris tendon. The incision terminates an inch or less above the pisiform bone (Fig. 314). Care must be taken to avoid any tributary of the superficial ulnar vein which may be over the line of the artery. The deep fascia—which is here very slender—is exposed and divided.

The tendon of the flexor carpi ulnaris muscle is now displayed. The wrist is a little flexed to relax the tendon, which is gently drawn inwards by a blunt hook. The vessels are now exposed. The artery in this situation is bound down to the flexor profundus by a definite layer of fascia. This must be carefully divided. The nerve is close to the artery, and upon its inner side (Fig. 316). It may be impossible to isolate the artery from the companion veins. The needle is passed from within outwards. The palmar cutaneous branch of the ulnar nerve lies upon the artery in this situation, and must be avoided.

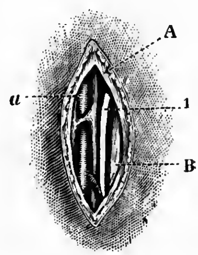

FIG. 316. — LIGATURE OF THE RIGHT ULNAR AT THE WRIST.

A, Fascia; B, Edge of flex. carp. uln. tendon; *a*, Artery; 1, Ulnar nerve.

Comment.—It is possible that the operator may expose the inner side of the flexor carpi ulnaris tendon by mistake. On this (the wrong) side of the tendon, muscular fibres will be found entering the tendon almost down to the wrist. On the radial side the tendon is quite clear. Care must be taken not to wound the synovial sac which accompanies the flexor sublimis digitorum tendons beneath the annular ligament. The posterior carpal arises a little above the pisiform bone.

2. **Ligature in the Middle Third of the Forearm.** *Operation.*—An incision, from two and a half to three inches in length, according to the muscular condition of the limb, is made precisely in the line of the artery (Fig. 314). Beneath the integuments the anterior ulnar vein and branches of the anterior division of the internal cutaneous nerve are apt to be encountered. The deep fascia is thin, and is divided in a line parallel with, but a little to the outer side of the line of, the skin incision.

The surgeon now seeks for the gap between the flexor carpi ulnaris

muscle and the flexor sublimis digitorum (Fig. 317). The position of this interval is sometimes indicated by a white line. (*See Comment* upon the operation.) The gap is, however, best demonstrated by the touch, the left forefinger being used for the purpose. As soon as the intermuscular space has been made evident, the wrist is a little flexed to relax the muscles. The flexor carpi ulnaris is now drawn inwards by means of a broad-bladed retractor. The flexor sublimis is in like manner drawn a little outwards. The surgeon opens up the vertical intermuscular space thus demonstrated, and at the bottom of it will probably first be found the ulnar nerve. To the outer side of the nerve is the artery (Fig. 318). The fascia binding down the vessels in this situation is slender. There is usually no difficulty in separating the artery from its venæ comites.

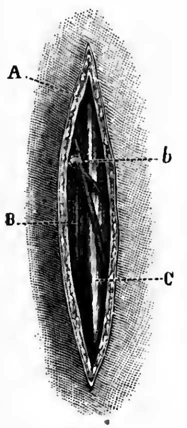

FIG. 317. — LIGATURE OF THE RIGHT ULNAR AT THE MIDDLE THIRD OF THE FOREARM.

Superficial Wound.— A, Fascia; B, Palmaris longus; C, Flex. ulnaris; *b*, Superficial vein.

The needle should be passed from within outwards, so as to avoid the nerve.

Comment.—This operation is associated with considerable difficulty if carelessly performed, and the procedure is surrounded by many possibilities of error.

The chief difficulty is to demonstrate the gap between the flexor carpi ulnaris and flexor sublimis muscles.

The "white line" which is said to mark this gap is not to be relied upon. There may be no trace of such a line; it may be very faintly indicated, or the position of the interspace may be marked by a yellow fatty line. The white line is best seen in young muscular subjects. In the aged and wasted it is usually absent. In corpulent subjects the linear deposit of fat is commonly present.

The white line, when it does exist, indicates the tendinous margin of the flexor carpi ulnaris. This tendinous tissue belongs to the tendon of origin of the muscle, and not to that of the insertion, as usually stated. At the level of the centre of the forearm there is seldom any trace of the tendon of insertion. A faint variety of the white line is sometimes produced by an unusual intermuscular septum. The flexor carpi ulnaris is much more closely adherent to this septum than is the flexor sublimis, and when the fascia is divided the septum adheres to the former muscle, thus producing a species of fascial margin.

The interspace between the two muscles in question is not quite straight, i.e. is not quite vertical when the limb is in position for the operation. The flexor carpi ulnaris overlaps the flexor sublimis a little, and the line of the interspace is directed as is shown at *a* in Fig. 319. The fibres of both the muscles follow the long axis of the limb.

If the division of the deep fascia be exactly in the line of the skin incision, i.e. in the line of the artery *x*, the knife will probably cut upon the flexor carpi ulnaris.

By dividing the fascia a little more to the outer side as advised, the knife comes upon the flexor sublimis (Fig. 319), and by working inwards the oblique gap between the muscles is made out. This gap is always best demonstrated by the finger. It is often indicated by one or more cutaneous arteries which escape here and form an excellent guide to the main artery. The interspace should be sought for at the lower part of the wound, and the separation of the two muscles should take place from below upwards. It may be noted that the flexor sublimis at the middle third of the forearm presents a few fine commencing tendon fibres.

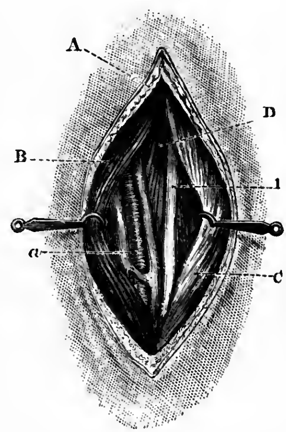

FIG. 318.—LIGATURE OF RIGHT ULNAR ARTERY AT THE MIDDLE THIRD OF THE FOREARM.

Deep Wound. — A, Fascia; B, Flex. sublimis; C, Flex. carp. ulnaris; D, Flex. profundus; *a*, Artery; 1, Ulnar nerve.

In muscular subjects care should be taken that the incision is made long enough.

It is only by the display of great carelessness that it would be possible to open up the interspace between the flexor sublimis and palmaris longus muscles.

When the proper interval has been found between the flexor sublimis and the flexor carpi ulnaris, it is not uncommon for the beginner—impressed with erroneous views as to the depths of the artery—to proceed too deeply and too far to the inner side, and to actually pass by the ulnar nerve and open up the interspace between the flexor carpi ulnaris and the flexor profundus digitorum. (*See* Fig. 319, *b*.) This may readily happen if the former muscle be dragged too much to the inner side.

Collateral Circulation after Ligature of the Radial or Ulnar Artery.—After ligature of one of these vessels, the collateral

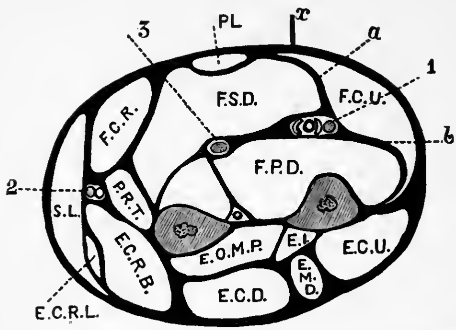

FIG. 319.—TRANSVERSE SECTION OF THE FOREARM (DIAGRAMMATIC), TO SHOW THE INTERMUSCULAR SPACES ABOUT THE MIDDLE THIRD.

Initials indicate the tendons and muscles. *a*. Ulnar artery interspace; *b*, Interspace to be avoided; *x*, The surgical line of the ulnar artery; 1, Ulnar vessels; 2, Radial vessels; 3, Median nerve.

circulation is very readily and freely established, through the cross anastomoses between the arteries in question, through the palmar and carpal arches, and through the interosseous vessels.

Varieties of the Radial and Ulnar Arteries.

1. The radial has been found outside the fascia, and subcutaneous.

2. The ulnar may be subcutaneous or subfascial in its entire course.

3. The median artery may be of large size and be largely concerned in the supply of the palm.

4. The radial artery may be absent.

THE BRACHIAL ARTERY

Anatomy.—The brachial artery commences at the lower margin of the teres major, and bifurcates at a point on a level with the neck of the radius. It lies in the depression along the inner borders of the coraco-brachialis and biceps muscles.

In the upper two-thirds of its course it lies on the inner aspect of the shaft of the humerus, and can be compressed against the bone by pressure in a direction outwards and slightly backwards. In its lower third the humerus is behind it, and compression, to be effectual, should be directed backwards. It runs between the skin and deep fascia as far as the elbow, where it dips into the interval between the supinator longus and pronator teres muscles, and passes beneath the bicipital fascia. In muscular subjects the artery may be overlapped to a considerable extent by the edge of the biceps.

It lies, in order from above downwards, upon the long head of the triceps (the musculo-spiral nerve and superior profunda artery intervening), the inner head of the triceps, the insertion of the coraco-brachialis (at the middle of the arm), and the brachialis anticus. It is fixed to the latter muscle by its sheath.

It is accompanied by venæ comites, one on each side, which are connected with one another by many transverse branches. The inner of these veins is much the larger. The basilic vein lies to the inner side of the artery, but is separated from that vessel, in the lower part of the limb, by the fascia. It pierces the fascia about the middle of the arm. It may then attend the artery to the axilla, or may join at once with the inner of the two venæ comites.

The median nerve crosses in front of the artery about or below its middle, lying to the outer side of the vessel above that point, and to its inner side below.

The ulnar nerve is to the inner side of the artery as far as the insertion of the coraco-brachialis ; it then leaves the vessel to run to the gap that lies between the internal condyle and the olecranon.

The internal cutaneous nerve lies in front or to the inner side of the artery, in about the upper half of its course. The nerve pierces the fascia, and becomes subcutaneous about the middle of the arm.

At the bend of the elbow the biceps tendon can be well felt, its outer edge being more evident than the inner. The crease in the skin called the " fold of the elbow " is placed some little way above the line of the articulation. At the spot where the biceps tendon ceases to be distinctly felt, and at the outer side of that tendon, the median, median basilic, median cephalic, and deep median veins join. The median basilic vein passes in front of the biceps tendon, the brachial artery, and the median nerve. The median basilic vein may cross the artery abruptly and be comparatively free of it except at the point of crossing, or it may run for some distance quite in front of the artery, or, crossing it early, it may lie parallel with the vessel, although at a different level, for the greater part of its course.

Line of the Artery.—When the arm is extended and abducted with the hand supine, the brachial artery corresponds to a line drawn from the outlet of the axilla (at the junction of its middle and anterior thirds) to the middle of the bend of the elbow.

Indications.—The artery is rarely ligatured at the bend of the elbow except for wounds and for traumatic arterio-venous

aneurysm. In the arm it has been secured for wound, for persistent hæmorrhage from the palmar arches, especially the superficial one, and for traumatic aneurysm. Spontaneous aneurysm is very rare in the brachial artery. Dr. Holt (*Amer. Journ. Med. Sciences*, April, 1882) only succeeded in collecting thirteen cases of such aneurysm.

Position.—In securing the artery at the bend of the elbow, the limb, extended and abducted, may be allowed to rest upon the olecranon. It should not be over-extended.

In dealing with the vessel in the arm, the limb should be extended and abducted, with the hand supine, and should be held away from the body. The arm itself should not be supported in any way, but the limb should be held by the forearm by an assistant.

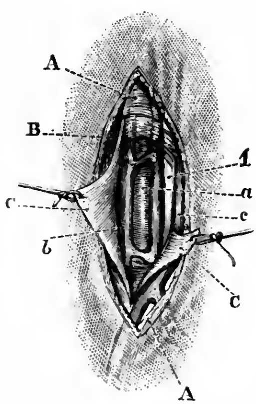

FIG. 320.—LIGATURE OF THE RIGHT BRACHIAL AT THE BEND OF THE ELBOW.

A, Fascia; B, Biceps tendon; C, Bicipital fascia; *a*, Artery; *b*, Venæ comites; *c*, Basilic vein; 1, Median nerve.

The surgeon may make the incision from above downwards on both sides of the body, standing to the outer side of the limb on the right side, and between the trunk and the limb on the left side. Or on the left side the operator may place himself to the outer side of the limb, and, bending over it, may make the incision from below upwards.

1. **Ligature at the Bend of the Elbow.** *Operation.*—The arm having been placed in the position indicated, the surgeon, by flexing and extending the limb, makes out the exact position of the biceps tendon, and by compressing the veins of the upper arm renders evident the median basilic vein.

An incision, two inches in length, is made through the skin, along the inner edge of the biceps and parallel with its margin. The wound will therefore be oblique, and it should be so placed that its centre corresponds to the mark on the skin which is called the "fold of the elbow" (Fig. 314). The upper end of the incision will correspond to the level of the tip of the internal condyle. If the veins be normally disposed, the skin

wound will lie to the outer side of the median basilic vein, and nearly parallel to it.

As soon as the vein is exposed it should be drawn inwards. The bicipital fascia is then demonstrated, and divided in the line of the original incision. Its fibres are directed obliquely downwards and inwards.

The artery, with its venæ comites, will now be exposed. The vessel will here be found to be very movable and free from connective tissue attachments, although sometimes surrounded by much fat (Fig. 320).

The venæ comites having been separated, the needle is passed from within outwards. The median nerve does not come conspicuously into the field of the operation. It is nearest to the artery (on its inner side) at the upper part of the wound.

Comment.—The median basilic vein is closely attached to the thin integument, and, unless made quite evident, may easily be wounded.

2. **Ligature at the Middle of the Arm.** *Operation.*—The limb having been placed in the position indicated, an incision about two and a half inches in length is made along the inner edge of the biceps muscle, in the line of the artery (Fig. 322).

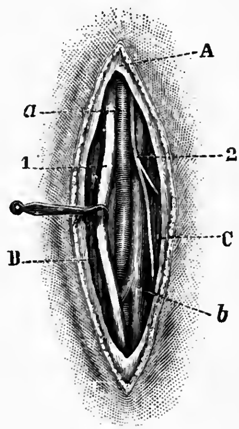

FIG. 321.—LIGATURE OF THE RIGHT BRACHIAL AT THE MIDDLE OF THE ARM.

A, Fascia; B, Biceps; C, Triceps; *a*, Artery; *b*, Vena comes; 1, Median nerve; 2, Internal cutaneous nerve.

The fascia, which is here thin, is exposed and divided, and the muscular layer is reached. It is extremely important that the inner margin of the biceps be clearly exposed and surely identified. The muscle is displaced a little outwards, and the pulsation of the vessel is sought for. A little dissection exposes the median nerve—if it be not already in view (Fig. 321). In the middle of the arm the nerve usually lies in front of the artery. In applying a ligature to any part of the brachial, at or above the middle of its course, the nerve should be drawn outwards. If the brachial be exposed below the middle section, the nerve is more conveniently displaced inwards.

While the artery is being exposed the elbow may be flexed for a moment.

The sheath of the artery having been opened, and the venæ comites separated as well as possible, the needle is passed from the nerve. The inner of the two companion veins is usually much the larger.

In the upper part of its course the inner margin of the coraco-brachialis muscle is exposed in the place of the biceps, and the ulnar nerve is lying to the inner side of the vessel.

Comment.—This artery is by no means so easy to ligature as may appear ; and in an operative surgery class no more glaring mistakes are made than occur in the course of searching for this superficial vessel.

In the first place, the arm should be unsupported, and be at right angles to the trunk. If the arm be allowed to rest upon a table, the triceps may be pushed forwards, and may be then mistaken for the biceps ; while the ulnar nerve has been mistaken for the median. This observation especially applies to the middle third of the limb.

The vessel is mobile, and is easily displaced, and in drawing the biceps aside roughly with a retractor, the vessels and the median nerve have been withdrawn from the field of the operation, and possibly the ulnar nerve brought into view. The clear identification of the biceps margin is essential. The advice sometimes given, that the " sheath of the muscle " should not be opened, is neither sound nor very precise.

The pulse in the brachial is often much feebler than would be imagined ; and this is especially the case in dealing with severe hæmorrhage. The pulsation may be so clearly transmitted to the median nerve that that nerve has been mistaken for the artery. It is asserted that the basilic vein has been mistaken for the artery. Tillaux states that a large inferior profunda artery has been taken for the brachial.

If the incision be made too much to the inner side of the proper line, the basilic vein may be wounded, especially when it is superficial, i.e. in the lower segment of the arm.

In very muscular subjects the biceps may overlap the artery considerably. The frequent abnormalities of the brachial must in all instances be borne in mind.

Collateral Circulation after Ligature of the Brachial Artery.

1 If above the origin of the superior profunda.

Above		*Below*
Posterior circumflex	with	Ascending branches of superior profunda.

2. If below the origin of the inferior profunda.

Above		*Below*
Superior profunda	with	Anastomotic. Radial recurrent. Posterior interosseous recurrent.
Inferior profunda	with	Anastomotic. Posterior ulnar recurrent. Posterior interosseous recurrent.

Varieties of the Brachial Artery.

1. The artery may run towards the inner condyle, and pass beneath a supracondyloid process.
2. The artery may show a high division. The branch prematurely separated will be the radial, the ulnar, the interosseous, or a vas aberrans.

   The site of the high division is most usually in the uppermost third of the arm, less often in the lower third, and most rarely in the middle third. The two vessels usually run side by side, the abnormal artery being the more superficial.

3. The median nerve may pass behind the brachial artery.
4. The vessel may be crossed by a muscular slip derived from the pectoralis major, biceps, coraco-brachialis, or brachialis anticus.

THE AXILLARY ARTERY

Anatomy.—The axillary artery extends from the lower edge of the first rib to the lower margin of the teres major muscle.

Its position is much influenced by the position of the arm. The vessel is conveniently divided into three parts—the segment above the pectoralis minor, the segment beneath the muscle, and the segment beyond the muscle. The first part measures about one inch in length, the second one inch and a quarter, and the third part about three inches.

The *first part* of the artery is deeply placed, is covered in by the pectoralis major and costo-coracoid membrane, and is invested by a fairly substantial sheath. It is overshadowed by

the clavicle and the subclavius muscle. It rests upon the first intercostal space, the second rib, the second and third serrations of the serratus magnus muscle, and the nerve of Bell. Crossing over the front of the vessel from without inwards are the cephalic vein, the acromio-thoracic vein, and the external anterior thoracic nerve.

The cords of the brachial plexus lie to the outer side of the vessel.

The axillary vein is of large size, is influenced, as to its dimensions, by respiratory movements, is superficial to the artery, and is placed on its inner side. When the arm lies by the side the vein is actually to the inner side of the artery; but when the limb is held at right angles to the body the vein is drawn across the artery and, in the living subject, conceals it.

The vein is somewhat closely attached to the costo-coracoid membrane.

The acromio-thoracic and superior thoracic arteries are given off from this part of the vessel. The upper border of the pectoralis minor is represented by a line drawn from the third rib, near its cartilage, to the coracoid process. The lower border of the muscle follows a line drawn from a corresponding part of the fifth rib to the same process.

The *second part* of the artery requires no notice.

The *third part* is covered by the pectoralis major at first, and then only by the integuments and fascia. It rests upon the subscapularis and the tendons of the latissimus dorsi and teres major. The circumflex and musculo-spiral nerves pass behind it. The coraco-brachialis muscle lies to its outer side, and the axillary vein to its inner side. This vein is formed by the junction of the two venæ comites. This junction is usually not effected until the lower border of the subscapularis muscle is reached. Thus two veins are commonly found in relation with the lowest part of the artery, and if the basilic vein has not yet joined the inner vena comes, three veins may be met with. The subclavian vein, in the form of a single trunk, may not have an existence until the region of the clavicle is reached.

The ulnar nerve lies to the inner side of the artery, between it and the vein. The nerve of Wrisberg is placed to the inner side of the vein. The internal cutaneous nerve and the inner

head of the median are in front of the artery, while the trunk of the median and the musculo-cutaneous lie to the outer side.

The internal cutaneous and the median are the nerves most closely connected with the artery.

The subscapular, posterior, and anterior circumflex arteries come off from the third part.

Line of the Artery.—A line from about the centre of the clavicle to the humerus, close to the inner border of the coraco-brachialis, will represent the artery when the arm is so abducted as to be at right angles to the body.

Indications.—The ligature of the axillary artery is practically limited to its third part. The artery has been tied for wound, for hæmorrhage from the limb below, for axillary and brachial aneurysm, and for the treatment of subclavian aneurysm, by the distal operation.

The axillary appears to have been first tied by R. Chamberlaine, of Jamaica, for traumatic aneurysm of the axilla, in 1815 (*Med.-Chir. Trans.*, vol. vi., page 128). The first part of the vessel was secured, and the operation was successful. Dr. Holt (*Amer. Journ. Med. Sciences*, 1882) reports a ligature of the first segment of the artery for the relief of hæmorrhage attending a ligature of the third part. The patient did well. In exceedingly few instances, however, has the first segment been secured, and in very few have the results been encouraging. In a case of aneurysm of the whole subclavian I (J. H.) ligatured the first part of the axillary, having first ascertained by incision that no ligature could be placed on the proximal side of the aneurysm. No difficulty was met with in the operation; there was no subsequent complication, and the aneurysm was apparently cured six months later. In a similar case recorded by Mr. Lediard (*Clin. Soc. Trans.*, 1900, page 246), however, no improvement resulted; and this would appear to be the rule.

1. **Ligature of the Third Part.** *Operation.*—The patient is placed upon the back, close to the edge of the table, and has the shoulders raised. The arm is at right angles to the body, and is held horizontally.

The surgeon may place himself between the arm and the thorax when about to secure either artery. It is the practice

of some to stand to the outer side of the limb, near the patient's head, and to bend over the extremity when operating upon the right axillary. The axilla must be shaved and made aseptic.

An incision, about three inches in length, is made along the line of the artery. It commences at the middle of the outlet of the axilla, at the junction of its anterior and middle thirds, and is continued down along the inner margin of the coraco-brachialis muscle (Fig. 322). The knife should be held with the blade horizontal. After the integuments and fascia have been divided, the inner margin of the coraco-brachialis should be thoroughly exposed. This muscle, with the musculo-cutaneous nerve, is then drawn gently outwards. The position of the artery may now be determined with the finger. In exposing it

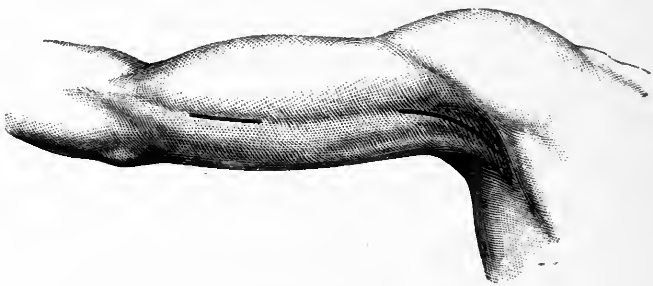

FIG. 322.—LIGATURE OF THE BRACHIAL ABOUT THE MIDDLE OF THE ARM, AND OF THE THIRD PART OF THE AXILLARY.

the median nerve is at once made evident, and should be drawn outwards by means of a small blunt hook. The internal cutaneous nerve should be gently displaced inwards. The venæ comites need to be well demonstrated. The artery having been cleared, the needle is passed from within outwards (Fig. 323).

Comment.—The numerous nerves in relation with this part of the vessel somewhat confuse the operation. The veins are apt to obscure the vessel. There may be three veins in relation with this part of the axillary—the two venæ comites and the still free basilic. Abnormalities in the artery must be anticipated. A muscular slip, passing from the latissimus dorsi to join the pectoralis major, biceps, or coraco-brachialis, may cross over the vessels. Such a slip may readily be mistaken, when large, for the coraco-brachialis muscle.

The ligature should not be applied too near any one of the branches of the artery.

2. **Ligature of the First Part.** *Operation.*—The patient lies upon the back, close to the margin of the table, with the upper part of the body raised. The point of the shoulder should be carried well back, and to effect this a hard cushion may be placed between the scapulæ. The arm is allowed to lie by the patient's side. It must not be dragged upon so as to depress the point of the shoulder.

The operator should stand upon the outer side of the limb, near the patient's trunk, when dealing with the left side, and near the head when dealing with the right. A good reflected light is necessary.

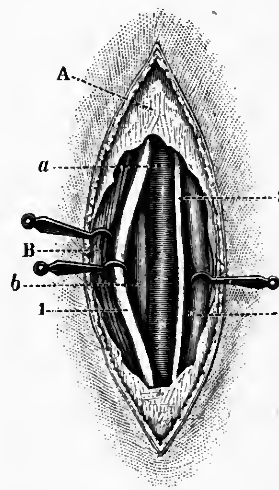

FIG. 323.—LIGATURE OF THE RIGHT AXILLARY (THIRD PART).

A, Fascia; B, Coraco-brachialis; *a*, Artery; *b*, Venæ comites; 1, Median nerve; 2, Int. cutaneous nerve.

A slightly curved incision, three inches long, with the convexity downwards, is made across the infraclavicular fossa. It passes about half an inch below the clavicle, and the centre of the incision is about opposite to the centre of that bone (Fig. 324).

The skin, platysma, supraclavicular nerves, and fascia are divided in the first incision. At the outer end of the wound care must be taken not to wound the cephalic vein and the large branch of the acromiothoracic artery.

The cephalic vein should be exposed, and forms a useful guide to the artery.

The outer edge of the pectoralis major is divided through its entire thickness close to the clavicle, and to the full extent of the original wound. The upper edge of the lesser pectoral should be defined, and may be drawn down if necessary.

The costo-coracoid membrane must now be dealt with. It should not be torn through, but should be divided vertically near to the coracoid process. The cephalic vein, if well brought out, will indicate the position of the axillary vein. The latter

vessel is readily torn in freeing a way through the costo-coracoid membrane. The internal anterior thoracic nerve, coming forwards between the axillary vein and artery, may, if seen, prove a guide to the latter vessel, the pulsation of which should, of course, be felt for.

The artery is now exposed, and the needle should be passed from the vein. The vein should be held aside with the finger while the needle is being passed.

It must be remembered that the vein is least in the way when the arm is by the side.

Comment.—There is great danger of tearing the axillary vein, and also of air being drawn into some of the smaller veins. If the pectoralis minor receive a slip from the second rib, the area of the operation is much curtailed. The cord or the brachial plexus nearest to the artery may be mistaken for that vessel.

The operation described may be considered as a modification of Chamberlaine's original proceeding.

Delpech made an oblique incision downwards along the gap which separates the pectoralis major from the deltoid, the wound starting from the clavicle. The two muscles were then separated from one another, the pectoralis minor divided near to the coracoid process, and the vessel drawn outwards and secured. The operation is needlessly difficult.

Collateral Circulation after Ligature of the Axillary Artery.

1. If the first part be ligatured above the origin of the acromio-thoracic, the collateral circulation will be the same as after ligature of the third part of the subclavian.
2. If the third part be secured below the circumflex vessels, the condition is the same as after ligature of the brachial above the superior profunda.
3. Ligature of the third part between the origins of the subscapular and the two circumflex.

Above		*Below*
Suprascapular Acromio-thoracic	with	Posterior circumflex.

4. Ligature of the third part above the origin of the subscapular. The same anastomoses as just given, with

Above		*Below*
Long thoracic Intercostals Posterior scapular Suprascapular	with	Subscapular.

Varieties of the Axillary Artery.

1. In one case out of every ten (R. Quain) the axillary gives off a large branch, which will be most frequently the radial, sometimes the ulnar, less frequently a vas aberrans, and very rarely the interosseous artery.
2. A trunk may arise from the third part of the artery from which will spring the subscapular, the two circumflex, and the two profunda arteries.

CHAPTER III

LIGATURE OF THE ARTERIES OF THE HEAD AND NECK

THE SUBCLAVIAN ARTERY

Anatomy.—The subclavian artery, starting from the aorta on the left side and the innominate on the right, arches across the lower part of the neck to reach the axilla. In the neck it usually reaches to the height of a point on a level with the sixth cervical vertebra. The length of the right artery is about three inches, the left about four. The latter vessel is a little smaller than the right. The diameter of the subclavian diminishes from 11 mm. to 9 mm.

The first part of the artery is considered to extend from the origin of the vessel to the inner edge of the anterior scalene muscle. The second part is that which lies behind the anterior scalene muscle, and the third part is that beyond the muscle.

The right subclavian and the cervical part of the left commence opposite the upper part of the sterno-clavicular joint. The *first part* of the artery is deeply placed beneath the integuments, the platysma, the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, and the cervical fascia. It is near to the trachea, is in contact with the pleura below and behind, and is in close relation with the innominate, internal jugular, and vertebral veins, the vagus, recurrent laryngeal, cardiac, and sympathetic nerves. The left subclavian is also in relation with the thoracic duct and the phrenic nerve. From this part of the artery arise the vertebral, the internal mammary, and the thyroid axis.

The *second part* of the artery reaches highest in the neck, and lies between the anterior and middle scalene muscles.

It is still in relation with the pleura, and is separated from the phrenic nerve by the anterior of the two muscles.

The superior intercostal artery arises from this part.

The *third part* of the subclavian represents the segment of the vessel which crosses the posterior triangle of the neck, and which is nearest to the surface. It is the part to which the ligature is applied. It runs in a triangle, the base of which is formed by the outer edge

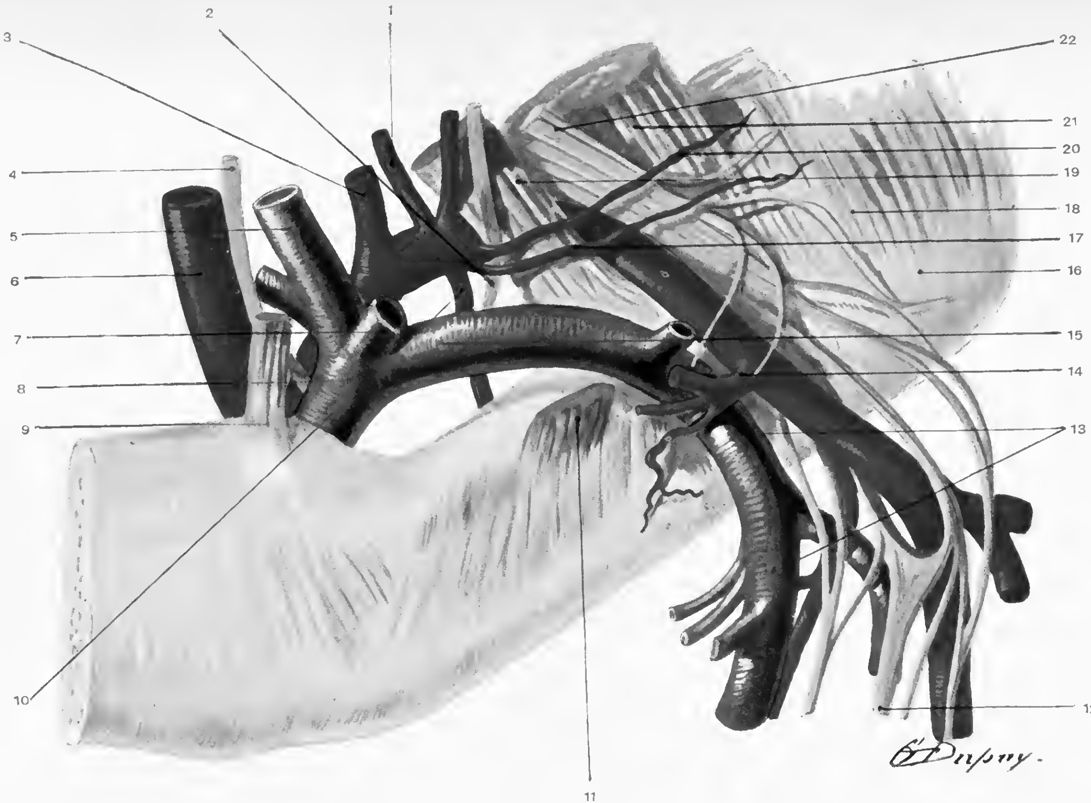

PLATE XXI.—LEFT SUBCLAVIAN ARTERY AND VEIN.

(From a Dissection in the London Hospital Museum.)

1, INFERIOR THYROID ARTERY. 2, PHRENIC NERVE. 3, VERTEBRAL ARTERY. 4, VAGUS NERVE. 5, INTERNAL JUGULAR VEIN. 6, CAROTID ARTERY. 7, EXTERNAL JUGULAR VEIN. 8, INNOMINATE VEIN. 9, STERNO-MASTOID MUSCLE. 10, INTERNAL MAMMARY ARTERY. 11, SUBCLAVIUS MUSCLE. 12, MEDIAN NERVE. 13, AXILLARY VEIN. 14, ACROMIO-THORACIC ARTERY. 15, SUBCLAVIAN VEIN. 16 AND 18, SERRATUS MAGNUS. 17, TRANSVERSE CERVICAL ARTERY. 19, ANTICUS SCALENUS. 20, SUPRASCAPULAR ARTERY. 21, SCALENUS MEDIUS. 22, BRACHIAL PLEXUS.

of the anterior scalene and the sides by the clavicle and omo-hyoid. The omo-hyoid is generally found about one inch above the clavicle in this situation. It may, however, be found almost level with the bone, or so high up as not to be encountered in the operation.

The third part of the artery is covered by the integuments and platysma, by the cervical fascia and a fibrous expansion which stretches from the omo-hyoid to the clavicle. It rests upon the first rib; the middle scalene muscle is behind it, the cords of the brachial plexus are above it. (*See* Plate XXI.)

The last cord, derived from the eighth cervical and the first dorsal, is nearest to the artery. The little nerve to the subclavian muscle crosses in front of the vessel, and nearer to the surface the supraclavicular nerves descend in front of the subclavian triangle.

The subclavian vein lies below the artery and anterior to it. It passes in front of the scalenus anticus (Fig. 325).

The external jugular vein is placed in front of the artery, although its relations to the vessel vary considerably. It receives in this region the transverse cervical and suprascapular veins, which may form a plexus over the subclavian artery.

The suprascapular artery lies behind and under cover of the clavicle. The transverse cervical artery crosses beneath the omo-hyoid muscle at some distance above the main vessel. The posterior scapular artery arises not infrequently from this part of the subclavian, the suprascapular very occasionally.

Indications.—A ligature has been applied to each of the three parts of the subclavian artery. So far as surgical experience at present extends, it may be said that the operation is rarely justifiable except in the third part of the artery.

A ligature has been applied to this portion of the vessel in cases of axillary aneurysm, in cases of wound, and in instances of hæmorrhage from the axilla. It has been applied also as a distal ligature in the treatment of innominate and aortic aneurysms, and as a preliminary step in excision of the scapula, in the removal of large axillary growths, and in amputation of the entire upper limb. The operation on the whole may be considered to be satisfactory, although the risks of secondary hæmorrhage and of intra-thoracic inflammation have been considerable. These risks are greatly reduced since wounds have been treated antiseptically. The mortality after ligature of the third part for axillary aneurysm is notably high, death following

frequently from suppuration of the sac and secondary hæmorrhage. Norris showed that in sixty examples of this operation the mortality was forty-five per cent.

Ligature of the third part of the artery was first attempted by Sir Astley Cooper in the spring of 1809. He was unable to complete the operation. In the autumn of the same year Ramsden ligatured the artery for the first time ("Practical Observations." London, 1811). The patient died. During succeeding years several surgeons carried out Ramsden's operation, but all the patients died. The first successful case was treated by Post, of New York, who operated in September, 1817 (*Med.-Chir. Trans.*, vol. ix., page 185). The first success in Great Britain was obtained by Liston in 1820 (*Edin. Med. and Surg. Journ.*, vol. xvi., page 348).

The first part of the subclavian was first ligatured by Colles in 1818. Ashhurst has collected nineteen examples of this operation, but not a single patient survived. In one case, that by Sir Mitchell Banks, the patient survived the ligature thirty-six days. In this instance the innominate had already been tied (Jacobson's "Operations of Surgery," page 537).

Ligature of the First Part of the Subclavian Artery.—This operation, so far as present experience goes, may be said to be very rarely justifiable. No artery could be less favourably placed for the application of a ligature. It is deeply situated, is near the heart, is in contact with the pleura, is surrounded by immense veins, and is in intimate relation with such nerves as the vagus, the phrenic, the recurrent laryngeal, and the cardiac. Moreover, the ligature is applied about a part of the vessel where numerous large branches are arising.

The method adopted has been similar to that carried out in exposing the innominate artery.

The **second part** of the vessel was ligatured by Dupuytren. He has had imitators, but Mr. R. Godlee is one of the very few surgeons who have performed this operation with success.

Ligature of the Third Part of the Subclavian Artery. *Position.*—The patient lies upon the back, close to the edge of the table, with the thorax raised and the head extended and turned to the opposite side.

The arm should be pulled well down and fixed. This latter

object is best effected by passing the arm behind the back whenever that is possible, and allowing it to remain fixed in that posture. The operator stands in front of the shoulder. A good light is necessary.

Operation.—The skin over the posterior triangle having been drawn down with the fingers of the left hand, an incision is made through it down to the clavicle. By adopting this plan all risk of wounding the external jugular vein is avoided. The incision, which is transverse, should be about three inches in length, and, when the traction upon the skin is withdrawn, should lie about half an inch above the clavicle (Fig. 324). It should extend across the base of the posterior triangle from the trapezius to the sterno-mastoid, and should be so planned that the centre of the wound shall correspond to a point about one inch to the inner side of the centre of the clavicle. This first incision divides the integuments, the platysma and the supraclavicular nerves, with possibly a vein which passes over the clavicle to connect the cephalic vein with the external jugular. The amount of trapezius and sterno-mastoid exposed will depend upon the extent to which those muscles are attached to the clavicle.

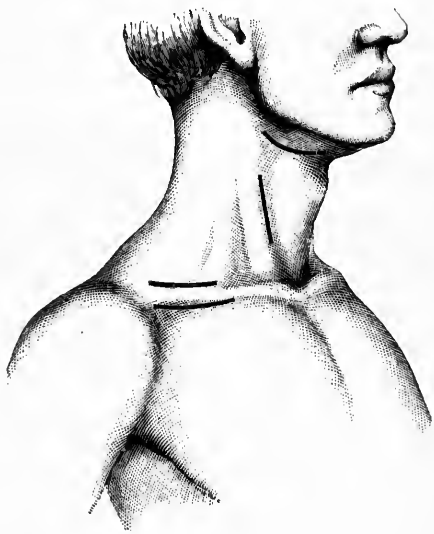

FIG. 324.—LIGATURE OF THE FIRST PART OF THE AXILLARY ARTERY, THE THIRD PART OF THE SUBCLAVIAN, THE COMMON CAROTID, AND THE LINGUAL.

The deep cervical fascia is now reached, and is divided in the length of the original wound. No director should be employed. If the surgeon cannot divide the fascia without the aid of this dangerous instrument he had better not attempt the operation. The external jugular vein must now be dealt with. Very probably it can be drawn aside and may be held by a small blunt hook towards the outer angle of the wound. If it obstructs

the area of the operation in a more determined manner, it may have to be divided between two ligatures. Sometimes, when an actual plexus of veins exists in front of the artery, much difficulty is encountered. All bleeding vessels must be secured. The wound throughout should be as bloodless as possible.

The outer margin of the anterior scalene muscle should next be defined, and the position of the omo-hyoid made out. The latter muscle, if at all in the way, must be drawn upwards. When the edge of the scalene muscle has been made plainly evident, the finger should be passed along it until the tubercle

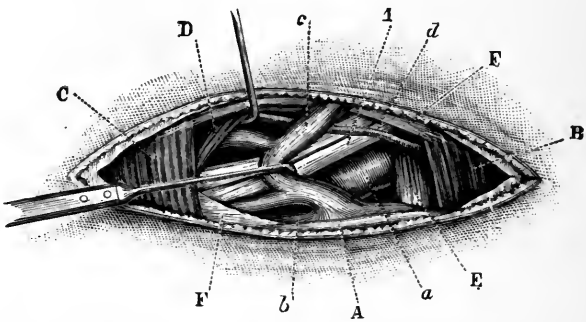

FIG. 325.—LIGATURE OF THE RIGHT SUBCLAVIAN ARTERY (THIRD PART).

A, Clavicle; B, Sterno-mastoid; C, Trapezius; D, Omo-hyoid; E, Anterior scalene; F, Cervical fascia; *a*, Subclavian artery; *b*, Subclavian vein; *c*, Ext. jugular vein; *d*, Transverse cervical artery; 1, Brachial plexus.

on the first rib is encountered. The finger will now be in contact with the artery, and its pulsations can be felt (Fig. 325).

The vessel will be found actually resting upon the bone. A little careful dissection will clear the artery and bring into view the lowest cord of the brachial plexus.

This nerve cord should be systematically exposed by a slight and careful dissection. It may be at once said that it has been the source of some of the more serious mistakes which may be made in this operation. The subclavian vein will be seen and felt, but it seldom encroaches much upon the field of the operation.

The transverse cervical artery runs high up, and will probably not come into view. The suprascapular artery keeps under cover of the clavicle. The fascia surrounding the subclavian is fairly substantial.

The needle (unthreaded) may now be very carefully passed from above downwards and from behind forwards. Its course must be directed by the forefinger of the left hand. By this finger the vein is protected and held out of the way. If the needle be passed from below—i.e. from the vein—it is easy to pick up the last cord of the plexus with the artery. The pleura has been wounded by a needle which has been carelessly passed. This accident cannot occur if the needle be passed between the artery and the upper surface of the first rib.

Comment.—The operation is difficult, and requires a steady hand and perfect control over the scalpel and forceps. The parts should be cautiously exposed by means of the knife and the vivisector's tool, and not by means of tearing and rending with the fingers and blunt instruments.

In order to obtain sufficient room, portions of the trapezius or of the sterno-mastoid may have to be cut.

The transverse cervical or suprascapular arteries may be in the way. They should be drawn aside, but in no case divided, as they play a most important part in the collateral circulation. These arteries have been injured during the operation, as have also been the external jugular vein and the phrenic nerve.

If the neck be short and the patient stout, the difficulties of the operation are much increased. Great difficulty will also be experienced when the veins have a plexiform arrangement or are engorged, and when the tissues are found to be œdematous and matted together.

The pleura has been several times wounded in passing the needle, and in many of the fatal cases where this accident is not noted the patient succumbed to intrathoracic inflammation. Both Liston and Green passed the ligature around the last cord of the brachial plexus by accident. South has seen the posterior scapular artery picked up and mistaken for the subclavian.

In very few instances does the subclavian vein appear to have been wounded.

Difficulties may be caused by the presence of a cervical rib or by an abnormality in the artery.

Collateral Circulation after Ligature of the Third Part of the Subclavian Artery.

Above		*Below*
Suprascapular Posterior scapular	with	Acromio-thoracic and subscapular
Internal mammary Aortic intercostals Superior intercostals	with	Thoracic and scapular branches of axillary.

Varieties of the Subclavian Artery.

1. Variations in the origin of the subclavian have little effect upon the third part of the artery.
2. A cervical rib may exist, and the artery be carried upon it, or upon the fibrous cord in which such ribs often terminate anteriorly.
3. The artery may reach as high as one inch or even (especially on the right side) one inch and a half above the clavicle, or may be so low as to be entirely under cover of the clavicle.
4. The artery may perforate the anterior scalene muscle, and in rarer cases may be in front of it.
5. The posterior scapular artery, and more rarely the suprascapular, may arise from the third part of the artery.

Ligature of the Subclavian after Division of the Clavicle.—Of late years it has been proved that division and excision of more or less of the clavicle greatly favour access to the subclavian artery. During the first stage of amputation of the entire upper extremity (Berger's operation) the vein and artery have been thus secured in a great many cases. Mr. Lediard, of Carlisle (*Clin. Soc. Trans.*, 1900, page 246), succeeded in excising a subclavian aneurysm between two ligatures after first resecting the middle two inches of the clavicle. The man recovered with a very useful arm—indeed, absence of part of the clavicle seems to make no great difference in the ability to use the limb. The excision should be carried out subperiosteally, and, as the aneurysm has probably encroached upon the posterior surface of the bone, great care should be taken not to open into the sac, as if this accident happened it might prevent the operation being completed and might readily cause fatal

hæmorrhage. Mr. H. W. Allingham was one of the first surgeons to perform this operation for aneurysm successfully (*Lancet*, June 3rd, 1899, page 1487).

THE INNOMINATE ARTERY

Anatomy.—This vessel has a diameter of about 14 mm., a length of from one to two inches, and is roughly represented by a line drawn from the centre of the manubrium to the sterno-clavicular joint. "The place of bifurcation would, in most cases, be reached by a probe passed backwards through the interval between the sternal and clavicular portions of the sterno-mastoid muscle" (Quain). The artery may divide at a point considerably below the clavicle, and, less frequently, at a point above it. The vessel may in rare instances give off the thyroidea ima, or even the internal mammary or bronchial arteries.

The innominate is separated from the sternum by the sterno-hyoid and sterno-thyroid muscles, the remains of the thymus gland, and, near its root, the left innominate vein.

It is in close connection with the trachea, and in still more intimate relation with the pleura. On the right side are the right innominate vein and the vagus nerve; on the left are the inferior thyroid veins and the left carotid artery.

Indications.—This vessel has been secured for the relief of carotid and subclavian aneurysms. The results, however, of the operation have been such that it is questioned whether it is to be considered as a justifiable surgical procedure.

It has happened to many surgeons to expose the innominate artery, with the intention of tying it for aneurysm of the neck, and then to draw back from putting the ligature round it on account of the dilated or otherwise diseased condition of the artery.

The success of distal ligature in such cases has usually made the surgeon thankful that he did not attempt the more dangerous ligature of the innominate. Prof. Gilbert Barling records two such instances of subclavian aneurysm. In both he exposed the innominate artery, but decided that its ligature would be fatal. In both cases the substituted operation, ligature of carotid and first part of axillary, proved a brilliant success. (Barling, *Lancet*, Sept. 16th, 1905, and Nov. 16th, 1907.)

So far as present experience extends as to the circumstances

which influence the success of the ligature of large arteries, it would appear that ligature of the innominate carries with it a better prospect of success—other things being equal—than does ligature of the first part of the subclavian. It is true that the innominate is deeply and inconveniently placed; it is true that the operation is exceedingly difficult; it is true that the vessel is nearer to the heart; but, on the other hand, the trunk gives off normally no branches, there is room for the application of the ligature, and the vessel is not in so intimate relation with such nerves as the vagus, the sympathetic, the phrenic, and the recurrent laryngeal, as is the first part of the subclavian.

Ashhurst collected twenty-four records of ligature of the innominate. Only two of the patients concerned survived the operation! One of these cases was under the care of Dr. Smyth, of New Orleans (*Syd. Soc. Bien. Retros.*, 1865–6, page 346). The patient, after exhibiting symptoms of secondary hæmorrhage, recovered and lived ten years. In the second case the operation was performed by Sir Mitchell Banks (Jacobson's "Operations of Surgery"), and the patient lived fifteen weeks. Mr. Jacobson, in the last edition of his work, mentions five cases of recovery.

In all the fatal cases death has followed from secondary hæmorrhage. Some patients have survived the operation many days. Thus Thompson's patient lived forty-two days, and Graefe's sixty-seven days. Both ultimately succumbed to secondary hæmorrhage.

Several of the operations included in the list have been performed within quite recent times and under the most approved antiseptic principles, but the results have not been substantially modified.

The great danger is from secondary hæmorrhage, which takes place apparently always from the vessel on the distal side of the ligature. Other complications have appeared, such as suppurative cellulitis, pericarditis, cerebral embolism, lung troubles, etc.

The first operation was performed by Dr. Mott, of New York, in 1818, for subclavian aneurysm. The patient died on the 26th day, of secondary hæmorrhage (*Med. and Surg. Register of New York*, 1818, page 8). An excellent summary of the chief cases is given by Mr. W. G. Spencer in a paper published in the *British Medical Journal*, July 13th, 1889.

Among the more recent cases is one by Dr. Lewtas for a wound produced by a bursting gun. It was successful (*Brit.*

Med. Journ., 1889, ii., 312). Successful applications of the ligature for aneurysm have been recorded by Mr. Coppinger (*Trans. Royal Acad. Med. Ireland,* 1893, page 243), Mr. Symonds (Jacobson's "Operations of Surgery," 1907), and Dr. Burrell (*Boston Med. and Surg. Journ.*, Aug. 8th, 1895). In a case operated on by Sir T. Myles (*Lancet,* Nov. 16th, 1907) the patient lived for a month, dying from secondary hæmorrhage from the carotid, which had been tied and divided at the time of the innominate ligature.

Operation.—The position of the patient and of the surgeon is the same as in the previous operation. A good light is essential, and an electric head-lamp should be in readiness. Several aneurysm needles, of different patterns and presenting several varieties of curve, should be provided.

An incision is made along the upper border of the inner third of the clavicle, and a second cut follows the anterior edge of the sterno-mastoid muscle. Each incision is at least three inches in length, and they join one another at an acute angle.

The skin and superficial structures having been divided, the flap marked out is dissected up.

The sterno-hyoid and sterno-thyroid muscles are now divided close to the sternum, together with so much of the sterno-mastoid as is exposed in the wound.

Care must be taken of the anterior jugular vein, which passes behind the last-named muscle near its origin. The vein is inconstant in size, and should be divided between two ligatures. The deep cervical fascia is exposed and divided in the line of the superficial wound. The operator now seeks for the common carotid artery, and having opened the sheath of that vessel as low down as possible, he follows it until he is led to the bifurcation of the innominate.

"It is now," writes Mr. Jacobson, "that the real difficulties may be met with. (1) Owing to engorgement of the venous circulation, increased by the anæsthetic, the internal jugular and innominate vein may be so much enlarged as to protrude into the wound. (2) An aneurysm may have extended under the artery and flattened it out so as to make it difficult of recognition. (3) The cellular tissue around the vessel and between it and the sternum may be so matted with adhesions as to make it difficult

to define the artery and its important relations on the right side —viz., vagus, pleura, and right innominate vein. (4) The artery itself may be enormously diseased and expanded. (5) The bifurcation of the artery may be quite an inch below the joint. In tracing down the innominate itself, the surgeon must keep his steel director most carefully on the front of the artery. In following the vessel down behind the sternum in order to find a site for his ligature, he will be aided by slightly flexing the head and by a laryngeal mirror or electric light. The cleaning the artery must be done with the utmost caution, especially on the outer side, owing to the important structures lying there. Of these the innominate vein and the vagus may be drawn outside, but it is only by keeping the director or needle-point very close to the artery here that injury to the pleura can be avoided."

The needle should be passed from without in, and a little from below upwards, so as to avoid the pleura as far as possible.

In order to avoid the chief danger of the operation—secondary hæmorrhage from the distal side of the ligature—the common carotid and the vertebral should be ligatured at the same time. The procedure involves, therefore, the securing of three arteries.

No drainage-tube should be used, and every possible means should be taken to bring about a primary healing of the wound.

Comment.—Much has been said upon the subject of the best ligature to use in this operation. So far as it is possible to form an opinion, the precise nature of the ligature would appear to be a matter of little importance, so long as it is strong enough and thoroughly aseptic.

We believe that kangaroo tendon (not chromicised) is on the whole the best material to employ. It is exceedingly strong, non-irritating, and supple.

Collateral Circulation after Ligature of the Innominate Artery.

	Cardiac Side		*Distal Side*
Trunk	First aortic intercostal	with	Superior intercostal of subclavian.
	Upper aortic intercostals	with	Thoracic branches of axillary, and intercostals of internal mammary.
	Phrenic	with	Musculo-phrenic of internal mammary.
	Deep epigastric	with	Superior epigastric of internal mammary.
Head	Free communication of vertebrals and internal carotids of opposite sides inside the skull. Communication of branches of opposite external carotids in middle line of the face and neck.		

THE INFERIOR THYROID ARTERY

Anatomy.—This vessel arises from the thyroid axis at the inner margin of the anterior scalene muscle. It passes upwards in front of the vertebral artery and longus colli muscles, and then, bending inwards and a little downwards, passes behind the common carotid, the internal jugular vein, the vagus, and the sympathetic (Fig. 326). The middle cervical ganglion rests upon it. The ascending cervical branch arises from the vessel just as it is about to pass behind the carotid. The ligature is applied to the artery on the distal side of this branch.

The recurrent laryngeal nerve is in close relation to the artery at its termination, and is nearly parallel to it at its commencement. The thoracic duct passes in front of the root of the left artery.

The inferior thyroid may arise direct from the subclavian, or have origin from the common carotid or vertebral. It may be double, or entirely absent.

The size, course, and situation of the vessel vary very greatly in cases of bronchocele.

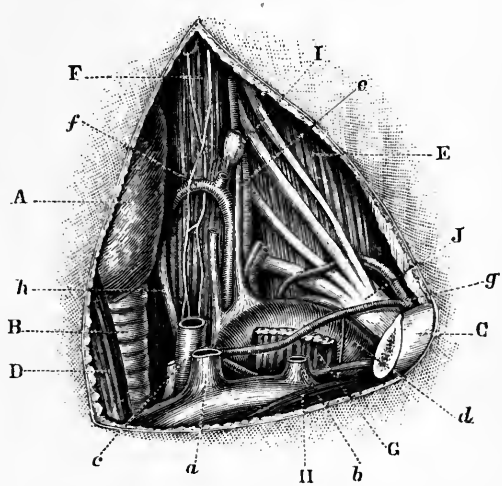

FIG. 326.—ANATOMY OF THE VERTEBRAL AND INFERIOR THYROID ARTERIES. (*Modified from Godlee's Atlas*).

A, Thyroid gland; B, Trachea; C, Clavicle; D, Sterno-thyroid; E, Scalenus medius; F, Longus colli, with sympathetic nerve upon it; G, Scalenus anticus (cut); H, Subclavius; I, Transverse process of sixth cervical vertebra; J, Brachial plexus; *a*, Left innominate vein receiving internal jugular; *b*, Ext. jugular vein entering subclavian vein; *c*, Common carotid artery, with vagus nerve to its inner side; *d*, Subclavian artery crossed by nerve to subclavius; *e*, Vertebral artery and vein; *f*, Inferior thyroid artery.

Indications. — The vessel is secured as a preliminary measure in removing the thyroid body, and in cases of injury. It has been ligatured also, together with the superior thyroid, for the purpose of arresting the growth, or of diminishing the size, of a bronchocele. The very free anastomoses between the thyroid vessels, and the dangers of the procedure, have rendered this measure very unsatisfactory. (*See* article by Wölfler, *Wien. med. Woch.*, 1886, and summary of thirty-one cases.)

Operation.—An incision, three inches in length, is made along the inner edge of the lower part of the sterno-mastoid muscle, just as in ligature of the common carotid low down. The wound reaches to the clavicle. The sterno-mastoid is exposed and drawn outwards, the carotid artery and its vein are reached and are drawn carefully *outwards*. The surgeon now seeks for the transverse process of the sixth cervical vertebra, and a little below that the artery may be discovered, passing inwards from behind the carotid (Fig. 326). It is ligatured close to the carotid, and in this way the immediate neighbourhood of the recurrent laryngeal nerve is avoided.

THE COMMON CAROTID ARTERY

Anatomy.—The right common carotid commences at the level of the sterno-clavicular articulation, and the cervical part of the left may be considered to commence at the same point. The vessel bifurcates opposite to the upper margin of the thyroid cartilage, on a level with the third cervical vertebra. The omo-hyoid crosses the carotid opposite to the lower margin of the cricoid cartilage, on a level with the sixth cervical vertebra.

The vessel *below the omo-hyoid* is deeply placed, being covered in front by the skin, platysma, fascia, sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles. This part of the artery may also be overlapped by the thyroid body. The anterior jugular vein passes in front of it, and the inferior thyroid artery and recurrent laryngeal nerve behind it.

The vessel *above the omo-hyoid* is superficial, being covered only by the skin, platysma, and cervical fascia, and overlapped by the inner margin of the sterno-mastoid muscle. This part of the artery is crossed by the sterno-mastoid branch of the superior thyroid artery, and by the superior thyroid vein. The middle thyroid vein will usually cross the carotid with the omo-hyoid muscle. The superior thyroid vein is often double, and may, in some cases, form a species of plexus in front of the carotid.

Along the inner border of the sterno-mastoid, below the hyoid bone, a vein generally runs which serves to connect the facial vein with the anterior jugular.

Behind the common carotid, in its entire course, are the cervical vertebræ, the longus colli muscle, and the sympathetic

nerve. Above the level of the cricoid cartilage, the rectus capitis anticus major muscle is also posterior to the artery.

The carotid sheath is derived from the cervical fascia, and is very substantial. It encloses the artery, the internal jugular vein, and the vagus nerve. Each of the three has its own especial investment. The nerve is posterior to both the artery and the vein, and its canal lies in the septum which separates these two vessels. The vein is to the outer side of the artery—on the right side the two become a little separated at the root of the neck, while on the left side the vein overlaps the artery slightly in that position. The right jugular vein is larger than the left, and the combined sectional areas of the two jugular veins are to those of the carotids as twenty to eleven. The descendens noni nerve descends along the front of the carotid sheath, inclining gradually from the outer to the inner side. The nerve frequently runs within the sheath. The sympathetic nerve is close to the carotid sheath behind.

Line of the Artery.—The course of the common carotid is represented by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process.

A valuable guide to the artery, at about the point of crossing of the omo-hyoid muscle, is afforded by Chassaignac's "carotid tubercle." This is the costal process of the sixth cervical vertebra, and the artery lies directly over it. It is to be found about two and a half inches above the clavicle.

Indications.—The common carotid has been tied for many different conditions. It has been ligatured on account of wound, on account of hæmorrhage arising from definite branches of the external carotid (e.g. the superior thyroid, lingual, temporal), and on account of bleeding generally from parts on the distal side of the vessel. Thus the carotid has been secured in cases of hæmorrhage from the orbit, the middle ear, the tongue, the mouth, the tonsil, the maxillæ, and in cases of cut throat, gunshot wound, and the like.

Unfortunately, ligature of this vessel is attended at all ages with considerable risk of hemiplegia, owing to deficient collateral circulation in the brain. Hence the common carotid should never be tied when ligature of its external division will suffice.

A ligature has been applied in cases of aneurysm of the external or internal carotid, in intracranial aneurysm, and in examples of angiomata involving the branches of the carotid. The distal ligature has been applied to the vessel in some instances of aneurysm of the aorta or innominate artery. The common trunk has been secured to restrain hæmorrhage, and to limit growth in the case of certain malignant tumours, and to check bleeding during the removal of such growths. The ligature of the carotid as a means of treating epilepsy has been abandoned as useless.

I (F. T.) have advocated the application of a temporary ligature or loop to the common carotid in instances where a permanent occlusion of the artery is not essential (*Lancet*, January, 1888). Prof. Crile has devised a clamp for the purpose.

The common carotid appears to have been first secured for hæmorrhage by Abernethy in 1798 (" Surgical Works," vol. ii.). The patient died. The ligature was successfully applied (for hæmorrhage) in 1803 by Fleming (*Med.-Chir. Journ.*, vol. iii.). Astley Cooper was the first surgeon to employ ligature of the common carotid as a means of treating aneurysm. His first operation was performed in 1805, and ended fatally (*Med.-Chir. Trans.*, vol. i.). His second case (1808) recovered.

The simultaneous ligature of both carotid and subclavian artery for aneurysm of the innominate artery or the aorta has been carried out extensively in England and France, though the procedure appears to be almost unknown in Germany. M. Poirier in 1900 collected records of 55 cases so treated. Twenty-eight (i.e. 50 per cent.) recovered, of which six were real cures, and in twenty-two improvement followed ; in some the patient lived for several years afterwards. The heavy mortality of the operation in cases of aneurysm (50 per cent.) should be noted.

The common carotid may be secured at any part of its course in the neck. The operations resolve themselves, however, into ligature above the omo-hyoid muscle and ligature below it. The former situation is in every respect to be preferred. Below the muscle the vessel is deeply placed, and has more complicated relations to structures of importance.

Farabeuf has well said that " below the omo-hyoid muscle the deaths are more numerous than the recoveries ; above, the recoveries preponderate over the deaths."

Position.—The patient lies upon the back, close to the edge of the table, with the shoulders raised and the hand of the affected side placed behind the back. The chin should be drawn up and the head turned a little to the opposite side. The surgeon stands upon the side exposed for operation.

1. **Ligature at the Place of Election (above the Omo-hyoid Muscle).** *Operation.*—The position of the cricoid cartilage having been defined, and the situation of the superficial veins made evident, an incision about three inches in length is made in the line of the artery, and is so placed that its centre is on a level with the cricoid cartilage (Fig. 327).

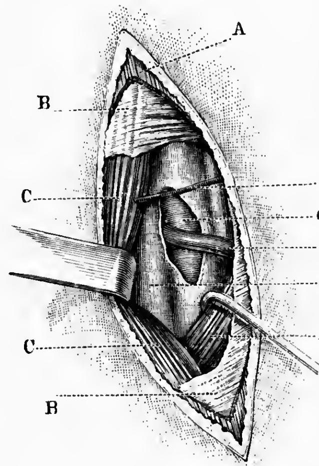

FIG. 327.—LIGATURE OF THE RIGHT COMMON CAROTID ABOVE THE OMO-HYOID.

A, Platysma ; B, Cervical fascia ; C, Sterno-mastoid ; D, Omo-hyoid ; *a*, Common carotid ; *b*, Sterno-mastoid artery ; *c*, Middle thyroid vein ; *d*, Internal jugular vein.

The skin and platysma having been incised (together with branches of the superficial cervical nerve), the surgeon divides the deep fascia along the anterior border of the sterno-mastoid muscle. Along this border a communicating vein between the facial and the anterior jugular may be met with. The edge of the muscle is defined, and is followed until the omo-hyoid muscle is made out. The superior border of this structure must then be well exposed, and the angle at which the two muscles meet be clearly demonstrated. The sterno-mastoid may be drawn a little outwards, and the omo-hyoid downwards.

The pulsations of the artery should now be sought for, and the vessel can usually be easily detected, as it crosses the conspicuous " carotid tubercle."

The artery is very mobile, and slips readily to and fro under

the finger. If the pulse be feeble it may present the physical characters of a flat cord.

In exposing the sheath of the artery, care must be taken to avoid the sterno-mastoid vessel and the superior or middle thyroid veins.

The sheath should be opened upon the inner side, and precaution taken not to damage the descendens noni nerve. Holding the sheath by the inner lip of the wound which has been made in it, the surgeon, with an unthreaded aneurysm-needle, should clear the artery upon its inner side. Holding, then, the outer lip of the sheath in the forceps, the outer side of the vessel can be cleared. By shifting the forceps as required, the whole circumference of the artery can be separated from its sheath. This process must be carried out with great care and with thoroughness.

The needle is passed from without inwards, is then threaded and withdrawn, bringing the ligature with it.

Comment.—In uncomplicated cases the operation is very simple. If the tissues are matted together, or are encroached upon by blood clot, or are displaced by a tumour or growth, the procedure may be attended with no little difficulty and risk.

If the head be turned too much to the opposite side, the sterno-mastoid is carried unduly far over the artery, and the border of the muscle may be missed.

The operation may be much complicated by the presence of large or distended veins. The internal jugular vein is of considerable size, is very thin, and is readily wounded. Its proportions are influenced by the respiratory movements, and, when the breathing is embarrassed, it becomes at one time enormously swollen, and at another moment flat and comparatively small.

Two other veins, though of less importance, may give trouble in the operation. One is the middle thyroid vein, which joins the internal jugular, passing outwards either over or under the artery. The other is a communicating vein between the facial or external jugular and the anterior jugular low down in the neck. It is inconstant, but is sometimes of considerable size, taking the place of the external jugular; as it runs, if

present, exactly in the line of the incision, it is sometimes troublesome.

The needle must be passed with great care. The artery has been transfixed by a needle which has been very roughly used. The descendens noni, the pneumogastric, and even the sympathetic cord, have been accidentally included in the ligature.

2. **Ligature below the Omo-hyoid Muscle.** *Operation.*—The position of the patient is the same as in the previous operation—that for ligature of the artery above the omo-hyoid. The incision is three inches in length, is in the line of the artery, and is so disposed as to have its commencement a little below the level of the cricoid cartilage, and its end a little above the sterno-clavicular joint. It follows the inner border of the sterno-mastoid muscle. Care must be taken to avoid the communicating vein from the facial, already described, and also the anterior jugular vein.

The sterno-mastoid is exposed and drawn outwards. The sterno-hyoid and sterno-thyroid muscles are likewise made evident, and are drawn inwards. The omo-hyoid, if seen, is relegated to the upper part of the wound.

It may be necessary to divide the sternal part of the sterno-mastoid, andt he whole or parts of the sterno-hyoid and sterno-thyroid muscles, especially if the ligature has to be applied as low down as possible. Retractors are needed to draw the muscles aside, and a good light is essential.

The inferior thyroid veins may prove to be very troublesome.

The sheath is opened on its inner side, as already described, and the needle is passed from without inwards.

Comment.—The observations made upon the previous measure apply in the main to the present proceeding.

The depth at which the vessel is placed renders the operation difficult and dangerous, and on the left side the surgeon's movements are apt to be complicated by the position of the internal jugular vein.

The relations of the inferior thyroid artery, and of the recurrent laryngeal nerve, must be borne in mind.

Collateral Circulation after Ligature of the Common Carotid.

Cardiac Side		*Distal Side*
Inferior thyroid	with	Superior thyroid.
Deep cervical	with	Occipital.
Transversalis colli	with	Occipital.

The communications between the two vertebral arteries and the branches of the two external carotid arteries.

The communications effected by the circle of Willis.

Varieties of the Common Carotid Artery.

1. Variations in the origin of the vessels have little effect upon their course in the neck.
2. The innominate may bifurcate higher (as a rule, lower) than usual.
3. The artery may bifurcate as high up as the level of the hyoid bone, or as low as the level of the middle of the larynx, or even of the cricoid cartilage.
4. The place of the common carotid may be taken by two parallel vessels—the external and internal carotids.
5. From the upper part of the artery the superior thyroid or ascending pharyngeal artery may arise.
6. The vagus nerve has descended in front of the artery.

THE EXTERNAL CAROTID ARTERY

Anatomy.—This artery extends from the level of the upper border of the thyroid cartilage to the level of the neck of the inferior maxilla. It is somewhat tortuous, but when rendered straight measures about two and three-quarter inches. It diminishes rapidly in size as it ascends.

About its origin it is covered only by the integuments, the platysma, and the cervical fascia, and at the same part it is overlapped by the sterno-mastoid muscle. It soon becomes deeply placed, and passes beneath the digastric and stylo-hyoid muscles, and ultimately through a portion of the parotid gland. In its upper part it is separated from the internal carotid by the styloid process, the stylo-pharyngeus muscle, and the glosso-pharyngeal nerve.

At the lower edge of the digastric muscle the hypoglossal nerve crosses in front of the artery. Below this nerve the facial

and lingual veins cross the vessel on its anterior aspect. Someway above the digastric the glosso-pharyngeal nerve passes obliquely behind the external carotid. The inframaxillary

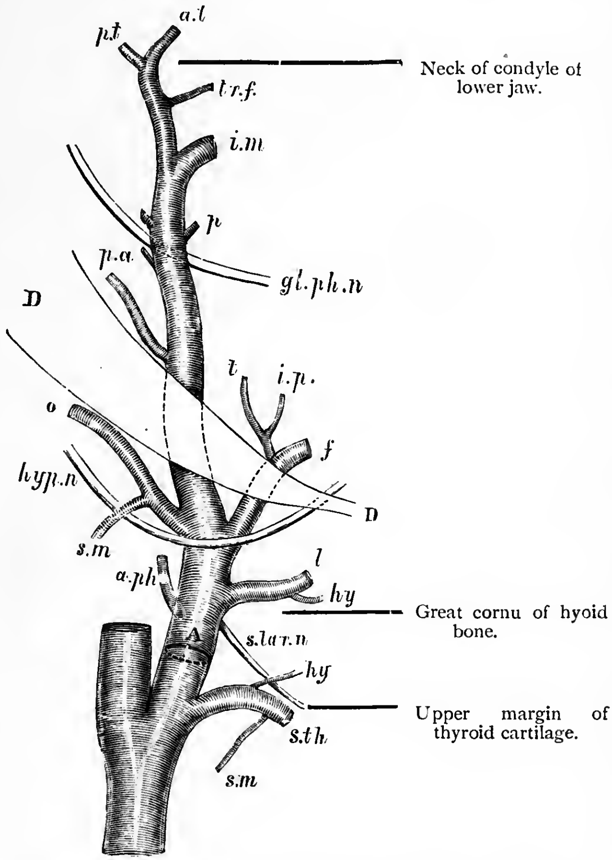

FIG. 328.—EXTERNAL CAROTID ARTERY, NATURAL SIZE. (*Modified from Quain.*)

a.t. and *p.t.*, Anterior and post. temporal arteries; *tr.f.*, Transverse facial; *i.m.*, Internal maxillary; *p*, Pharyngeal; *o*, Occipital; *p.a.*, Posterior auricular; *f*, Facial; *t*, Tonsillar; *i.p.*, Palatine; *s.m.*, Sterno-mastoid; *a.ph.*, Ascending pharyngeal; *l*, Lingual; *hy.*, Hyoid branch; *s.th.*, Superior thyroid; *hy.*, Its hyoid branch; A, Site of ligature of external carotid; D, Digastric muscle; *gl.ph.n.*, Glosso-pharyngeal nerve; *hyp.n.*, Hypoglossal nerve; *s.lar.n.*, Superior laryngeal nerve.

branches of the facial nerve are superficial to the artery above the digastric. The superior laryngeal nerve is placed obliquely behind the vessel near its origin.

The anterior division of the temporo-maxillary vein may pass

with the artery beneath the digastric muscle. More usually it lies superficially to that vessel.

The superior thyroid arises directly from the artery at its commencement. The lingual takes origin at a level with the greater cornu of the hyoid bone. The facial and occipital arise at the same level a little above the lingual.

Fig. 328 shows the artery at about its natural size, and serves to indicate the dimensions and position of the branches of the trunk, the intervals which separate their points of origin, and the relations of one branch to another. The more important landmarks in the course of the artery are also shown.

It will be observed that the digastric muscle crosses the artery about one inch and a quarter above its origin from the common carotid, and that the hypoglossal nerve crosses at about the height of one inch.

The segment between the bifurcation and the digastric muscle represents the most superficial and most accessible part of the artery.

Line of the Artery.—The external carotid is represented by the upper part of the common carotid line.

Others have proposed a line drawn from the tip of the lobule of the ear to the tip of the greater cornu of the hyoid bone.

Indications.—The artery has been ligatured for hæmorrhage following wounds and injuries, and involving the trunk or the branches of the vessel, for the cure of aneurysm and the relief of cirsoid aneurysm of the scalp. It has been ligatured as a palliative measure in the case of certain malignant growths, and has been secured as a preliminary measure to certain operations, e.g. removal of the maxilla, excision of parotid tumour, and the like. It is obvious that, in all cases of hæmorrhage from branches of the external carotid, that vessel should be secured whenever possible, in place of the common carotid. The operation is certainly less easy, but it is attended with an infinitely smaller mortality, the risks of secondary bleeding are reduced, and the brain complications, which are so frequent a cause of death after ligature of the common trunk, are avoided.

Operation.—The position of the patient and of the operator should be the same as in the previous operation.

The "place of election" is represented by the portion of

the vessel between the superior thyroid and lingual arteries (Fig. 329).

An incision, two and a half to three inches in length, is made in the line of the artery from a point about on a level with the middle of the thyroid cartilage to near the angle of the jaw. The greater cornu of the hyoid bone will be about the centre of the incision.

The integuments and platysma having been divided, and any superficial vein secured, the fascia is cut through, and the anterior border of the sterno-mastoid is exposed in the lower part of the wound. This muscle must be drawn outwards. The posterior belly of the digastric should next be sought for at the upper angle of the wound, and below it the hypoglossal nerve should be made evident. The surgeon now seeks with the finger for the tip of the great cornu of the hyoid bone, and when this is discovered all the "points" leading to the artery are in evidence (Fig. 329).

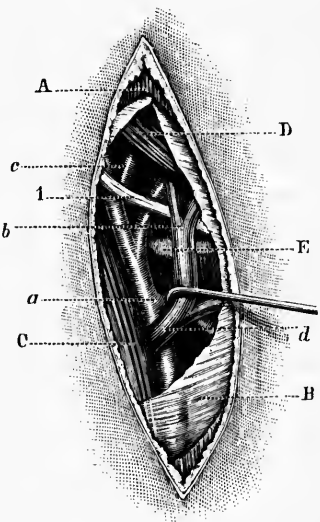

FIG. 329 —LIGATURE OF RIGHT EXTERNAL CAROTID ARTERY.

A, Platysma; B, Cervical fascia; C, Sterno-mastoid; D, Digastric; E, Great cornu of hyoid bone; *a*, External carotid at origin of superior thyroid; *b*, Crossing lingual artery points to lingual vein; *c*, Facial artery; *d*, Facial and superior thyroid veins; 1, Hypoglossal nerve.

The artery should now be exposed opposite to the level of the tip of the great cornu, and between the origins of the superior thyroid and lingual arteries. In this part of the operation care must be taken to avoid the facial and superior thyroid veins. Lymphatic glands may lie in front of the vessel. The artery having been cleared, the needle is passed from without inwards. In effecting this, great care must be taken to avoid the superior laryngeal nerve, which courses behind the artery in this situation.

Collateral Circulation after Ligature of the External Carotid.—(*See* the collateral circulation after ligature of the common carotid, page 382.)

Varieties of the External Carotid.

1. *See* the varieties of the common carotid.
2. The branches of the artery may be crowded together near the commencement of the trunk.
3. The number of branches may be diminished, two or three arising from one trunk.
4. The number of branches may be increased, subsidiary vessels arising from the main artery.

THE LINGUAL ARTERY

Anatomy.—This artery arises nearly opposite to the greater cornu of the hyoid bone, and about three-quarters of an inch above the bifurcation of the carotid. It ascends a little, and then, passing downwards and forwards, forms a curve (Fig. 329). It soon disappears beneath the digastric and stylo-hyoid muscles, and running forwards under the hyo-glossus, and along the upper border of the greater cornu of the hyoid bone, it reaches the anterior margin of that muscle, where it turns upwards to enter the under surface of the tongue.

The *first part* of the vessel extends from its origin to the posterior margin of the hyo-glossus muscle (kerato-glossus).

The *second part* is that which lies under the hyo-glossus muscle; and the *third part* is that slender portion of the vessel which extends beyond the anterior margin of the muscle (basio-glossus).

The *first part* is covered by the skin, platysma, and deep fascia, and by some of the cervical glands. It forms a kind of loop, which is crossed by the hypoglossal nerve, and by the facial and lingual veins. The digastric and stylo-hyoid muscles cross this segment of the artery before the hinder border of the hyo-glossus is reached.

This part of the lingual lies behind, upon the middle constrictor and the superior laryngeal nerve.

From the first part arise the hyoid and dorsalis linguæ branches, the former about half an inch from the origin of the artery, the latter near to the posterior border of the hyo-glossus, under cover of which border it ascends to the tongue.

The hyoid branch is inconstant, and may be absent.

The *second part* of the lingual lies beneath the hyo-glossus,

and has a nearly horizontal course. It rests upon the genio-glossus, and is placed below the level of the hypoglossal nerve, which is entirely superficial to it. The sublingual branches arise from this part, taking origin near the anterior border of the hyo-glossus muscle.

The *third part* of the artery takes the name of the ranine, and is distributed to the tongue.

The *veins* attending the lingual artery are divided into three sets. 1. The ranine vein, the largest, has a course independent of the artery. It runs on the superficial surface of the hyo-glossus, below the hypoglossal nerve, and about on a level with the lingual artery, which is beneath the muscle. 2. Two very small venæ comites accompany the artery in its course beneath the hyo-glossus. 3. Several veins usually attend the dorsalis linguæ artery, and often have a plexiform arrangement. These three sets of veins may enter into a common trunk, the lingual vein, but very frequently they enter separately into the internal jugular, or common facial veins.

The lingual artery may arise from the superior thyroid, or from the facial, or it may be replaced by a branch of the internal maxillary artery.

The vessel may run between the fibres of the hyo-glossus muscle, close to its origin from the bone.

Indications.—The lingual has been ligatured in cases of hæmorrhage following wound of the artery or its branches. The ligature has been employed to arrest bleeding in advanced cancer of the tongue, and to modify the growth of the cancer in cases unfitted for other operation. The lingual has been secured in the treatment of macroglossia. The most common circumstance, however, under which this vessel is tied, is as a preliminary measure in the removal of the tongue.

The artery may be secured in either the first or the second part of its course. In the former situation a ligature is but very rarely applied, the place of election being in the second segment of the vessel as it lies beneath the hyo-glossus muscle and occupies the digastric triangle.

Ligature of the Artery at the "Place of Election," i.e. *beneath the hyo-glossus muscle. Position.*—The patient lies close to the edge of the table, with the shoulders raised,

with the arm of the affected side passed behind the back, and with the face turned to the opposite side. An assistant must keep the chin drawn well upwards and the lower jaw fixed. The surgeon stands upon the side to be operated upon. The chief assistant is placed opposite to him, and leans over the patient's body. A second assistant stands by the surgeon's side. His chief duty is to hold the hook which commands the digastric tendon. The patient must be well anæsthetised before the operation is commenced. In male subjects the skin of the submaxillary region should be shaved.

Operation.—An incision, some two inches in length, curved, and with the convexity downwards, is made between the lower jaw and the hyoid bone. The wound commences a little below and to the outer side of the symphysis, and ends a little below and to the inner side of the point where the facial artery crosses the lower margin of the maxilla. Its centre is just above the greater cornu of the hyoid bone (Fig. 324). On the right side the incision is made from behind forwards, on the left side from before backwards.

The integuments, platysma, and superficial fascia are divided in the line of the incision. Certain superficial veins will be encountered, and some will probably have to be secured. These veins are the submental or other tributary of the facial, or some tributary of the anterior jugular.

It will now be convenient to apply ligature retractors, in order that the depths of the wound may be well laid open.

The next step is fully to expose the submaxillary gland. It is lodged in a special compartment of the cervical fascia. This fascia should be opened transversely over the lower part of the gland, and the organ should be cleared and brought well out into the wound by means of the finger and the handle of a scalpel. The gland should be turned upwards on to the margin of the jaw, and be kept out of the operation area by means of a broad and well-curved retractor held by the chief assistant.

The fascia exposed by the lifting out of the salivary gland is now to be divided transversely, and in the anterior angle of the

wound the posterior edge of the mylo-hyoid muscle must be sought for and defined.

The digastric tendon and the two bellies of the muscle are now to be brought clearly into view. Around the tendon, where it is nearest to the hyoid bone, a small blunt hook with a very long shaft or handle is to be passed and held by the assistant who stands at the surgeon's side. The tendon should be drawn downwards and towards the surface.

By this means the area of the operation is brought well into view, and is increased in extent; the parts are fixed; the hyoid bone, carrying with it the hyo-glossus muscle, is brought nearer to the surface, and the muscle in question is put upon the stretch.

The hyo-glossus muscle can now be easily made out, and its exposed surface freed of connective tissue. The hypoglossal nerve must be sought for, as it crosses the muscle, and the surgeon's work be limited to the segment of muscle below the nerve (Fig. 330) in the triangle formed by the hypoglossal above, the digastric behind, and the mylo-hyoid in front.

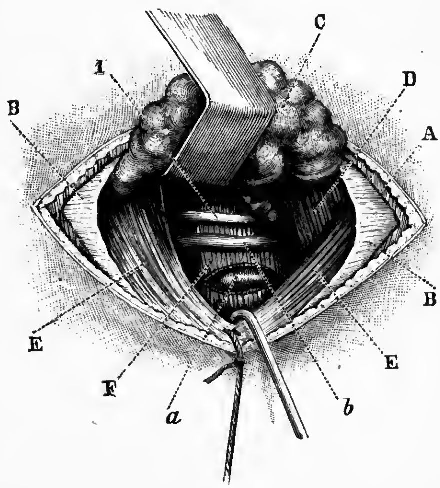

FIG. 330.—LIGATURE OF RIGHT LINGUAL ARTERY.
A, Platysma; B, Cervical fascia; C, Submaxillary gland; D, Mylo-hyoid; E, Digastric; F, Hyoglossus; *a*, Lingual artery; *b*, Ranine vein; I, Hypoglossal nerve.

Crossing the hyo-glossus below the nerve, and parallel with it, is the ranine vein. This vein will about correspond in position with the artery, which lies beneath the muscle.

The vein and the nerve should be displaced upwards.

The hyo-glossus muscle is divided transversely to the extent of about half an inch, a little above the margin of the hyoid bone, and parallel with it.

The incision in the muscular tissue must be cautiously deepened. If the cut has been well placed the artery will bend

out into the wound and make itself evident as soon as the whole thickness of the muscle has been divided.

The needle—unthreaded—is most conveniently passed from above downwards. In the ligature the minute venæ comites which attend the artery are no doubt included.

The wound is gently sponged, and the gland replaced. The edges of the incision are adjusted by sutures, but no drainage-tube is required.

Comment.—This operation requires a good light, and is only performed with ease and certainty when the procedure is carried out step by step.

The stages of the operation should be marked in succession by the following points. 1. The complete lifting up of the submaxillary gland. 2. The demonstration of the edge of the mylohyoid muscle. 3. The clearing of the digastric tendon, and the drawing of it outwards with a hook. 4. The demonstration of the hypoglossal nerve on the hyo-glossus muscle.

The incision may be of less dimensions than those given, or may be extended if required.

If the cut be carried too far back, the facial vein and artery are endangered. Time should not be wasted over the early part of the operation. Such veins as are cut may be clamped and left. They seldom require a ligature. The gland must be well exposed. The chief difficulties of the operation depend upon the gland. In many cases of ligature of the lingual artery in the neck the submaxillary gland has been removed first, and the procedure thus made more easy.

As soon as the gland has been turned out of its bed, steps must be taken to keep the wound quite bloodless. Other complications are afforded by a matting together of parts by a past inflammation, by the presence of unusual veins or of enlarged lymphatic glands.

As the wound becomes deep, and the area of the operation very narrow, a pair of long-bladed and fine dissecting forceps is needed.

The fixing of the digastric tendon and the hyoid bone by means of the small hook is an essential part of the operation. Embarrassed breathing may form a serious complication in the later stages of the procedure.

The hyo-glossus muscle varies in thickness ; the part divided is, in the main, the basio-glossus, and the beginner will find the muscle much thicker probably than he had imagined.

The lingual has been cut in dividing the muscle carelessly. The bulging of the artery into the wound in the muscle is very characteristic whenever the incision has been fortunate enough to be accurately placed. We know of no artery which, when exposed by operation, looks less like an artery than the lingual.

LIGATURE OF OTHER BRANCHES OF THE EXTERNAL CAROTID

The facial, temporal, or occipital arteries may require to be ligatured in cases of wound, and in still rarer instances of traumatic aneurysm. The two latter vessels have also been secured in the treatment of cirsoid aneurysm of the scalp.

It is unnecessary to detail in precise manner the various steps involved in the securing of these and other of the smaller arteries of the head and neck.

In most instances the operation is informal, and consists merely in picking up a bleeding vessel at the bottom of an existing wound, which at the most has been merely enlarged.

The Facial Artery has been ligatured in the neck, through an incision similar to that employed in exposing the external carotid artery, or the commencement of the lingual (Fig. 329). It is, however, most conveniently secured as it crosses the lower margin of the jaw (Fig. 331). A horizontal incision, one inch in length, is made across the course of the vessel, along, and under cover of, the inferior margin of the jaw. The artery crosses this margin at the anterior border of the masseter muscle. After the skin, platysma, and fascia have been divided, the artery should be in evidence, especially as its pulsations are readily felt. The facial vein is behind the artery, and very close to it. The needle should be passed from behind forwards.

A vertical incision in the course of the artery has been advised; but it exposes the vessel in a less convenient manner, and leaves a more conspicuous scar.

The Temporal Artery may be secured just in front of the meatus, as the vessel leaves the parotid gland. An incision one inch in length is made vertically, over the course of the vessel, between the tragus and the condyle of the jaw. The artery is ligatured

just above the root of the zygoma (Fig. 331). It is here covered by the skin and a dense fascia. A single large vein accompanies it, lying behind the artery and overlapping it. The vessel is crossed by branches of the temporo-facial division of the facial nerve, and lies over and behind the auriculo-temporal nerve. The needle is passed from behind forwards.

The temporal bifurcates about one inch and a quarter above the root of the zygoma.

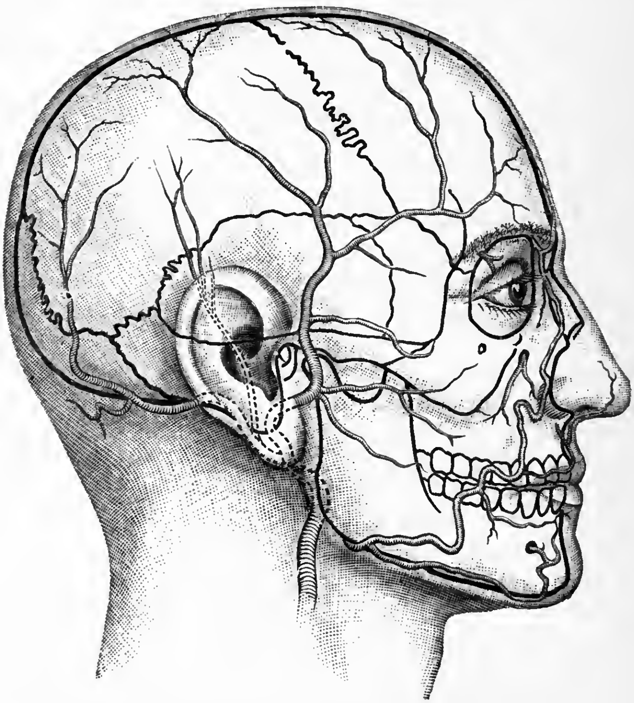

FIG. 331.—SHOWING THE POSITION OF THE FACIAL, TEMPORAL, AND OCCIPITAL ARTERIES. (*Modified from Merkel.*)

The Occipital Artery has been ligatured close to its origin, and also in that part of its course which lies beyond the mastoid process (Fig. 331). In the first position it is reached by an incision similar to that employed for exposing the external carotid (Fig. 329). That vessel is made evident, and the hypoglossal nerve, which winds round the occipital, is demonstrated.

In the second position a nearly horizontal incision, two inches in length, is made, which, commencing about the tip of the mastoid

process, is carried backwards and a little upwards. The skin and fascia having been divided, the muscles are exposed. The posterior fibres of the sterno-mastoid must be divided; the splenius is then cut, and so much of the tracheo-mastoid as may be necessary. The surgeon now feels for the interval between the mastoid process and the transverse process of the atlas, and exposes the artery as it escapes from beneath the digastric muscle.

A good light and suitable retractors are needed for this operation. Two small venæ comites attend the artery. Care must be taken not to injure the veins issuing from the mastoid foramen. The needle may be passed either from above or from below.

CHAPTER IV

LIGATURE OF THE ARTERIES OF THE LOWER LIMB AND THE ABDOMEN

THE DORSALIS PEDIS ARTERY

Anatomy.—The artery extends from the bend of the ankle to the posterior end of the first interosseous space. It lies on the tarsal bones—to which it is attached by an aponeurotic layer—between the tendons of the extensor pollicis and extensor communis digitorum. It passes beneath the lower bend of the annular ligament and the dorsal fascia of the foot. Near its termination it is crossed by the innermost slip of the extensor brevis digitorum.

Two venæ comites accompany the artery, and the inner branch of the anterior tibial nerve lies to its outer side. Occasionally the nerve is superficial to the artery.

Varieties of the Dorsalis Pedis Artery:

1. The artery may be wanting and its place be supplied by the anterior peroneal.
2. It may curve outwards below the ankle-joint, and return to its normal position at the back of the first space.
3. It may pass through the second space.

Line of the Artery.—From the centre of the front of the ankle—the centre of the intermalleolar space—to the middle of the first interosseous space.

Operation.—The patient lies upon the back. The limb is straight and the heel is steadied firmly on the table. The surgeon stands to the outer side of the limb in each case, cutting from above downwards on the right side and from below upwards on the left. One assistant stands on the opposite side of the table to steady the limb and to hold the foot in the position of full extension. Another assistant attends to the wound.

An incision, one inch and a half long, is made on the line of the artery, and commences at the lower border of the annular ligament. The cut will be midway between the tendon of the extensor pollicis and the innermost tendon of the extensor communis (Fig. 332). The dorsal fascia of the foot is divided in the same line. The artery—

often buried in much connective tissue—is found lying close to the bone. The ankle should be a little relaxed from the extended posture as the artery is sought for. The needle should be passed from the outer side to avoid the nerve.

Comment.—The operation is seldom required, except to tie a bleeding point. Aneurysm of the dorsalis pedis is occasionally met with. The tumour is usually placed over the scaphoid or internal cuneiform bone. Ligature of the artery above and below the aneurysm has been fairly successful. The inner division of the musculo-cutaneous nerve will be exposed in the subcutaneous tissue, and must be avoided. Care should be taken not to open the synovial sheaths of the two tendons between which the artery lies. The tarsal branch of the vessel arises opposite the head of the astragalus, and the metatarsal branch opposite the bases of the metatarsus.

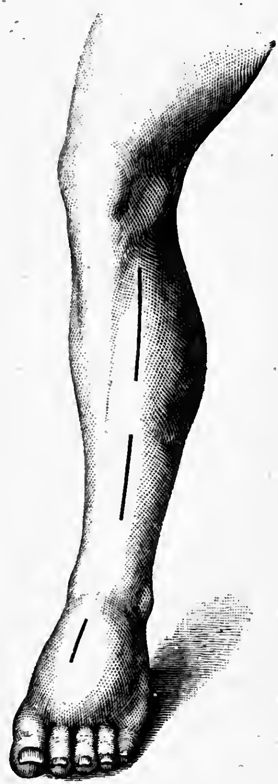

FIG. 332.—LIGATURE OF THE DORSALIS PEDIS ARTERY, AND OF THE ANTERIOR TIBIAL.

THE ANTERIOR TIBIAL ARTERY

Anatomy.—The vessel lies at first close to the inner side of the neck of the fibula. As it descends it gradually approaches the tibia, and at the lower third of the leg it lies in front of that bone. In the upper two-thirds of the leg the artery rests on the interosseous membrane, to which it is closely bound by connective tissue. It is at first very deeply placed, but at the lower third of the limb it becomes superficial. For the upper fourth the vessel lies between the tibialis anticus on the inner side and the extensor communis on the outer side. From thence to the lower end of the middle third of the leg it lies between the tibialis anticus and the extensor communis and extensor proprius pollicis, the latter being the more deeply placed. In the lower third, where the muscles become tendinous, it is crossed gradually by the extensor pollicis tendon, which ultimately lies to its inner side. The vessel here passes under the upper band of the annular ligament.

Two venæ comites accompany the vessel, one lying in front of

the artery, the other behind it. The anterior tibial nerve lies first to the outer side of the artery, then (for the greater part of its course) more or less in front of the vessel, and lastly once more to its outer side.

Line of the Artery.—From a point midway between the head of the fibula and the outer tuberosity of the tibia, to the centre of the front of the ankle-joint.

Indications.—The artery may be ligatured at any part of its course on the front of the leg. The ligature in the lower third is the most common. It is performed here for wound or for aneurysm. Ligature of the artery above the lower third is seldom called for, and is probably limited to cases of wound only. Aneurysms are rare, and are most usually met with at either the upper or the lower end of the artery, and not about the middle of its course. Ligature of the vessel in its lower third may be an auxiliary measure in some cases of bleeding from the foot. In punctured wounds of the upper third of the limb great doubt may exist as to which artery is divided, the anterior or the posterior tibial. In such instances it is a question whether position and pressure, followed possibly by the distal ligature, do not form a better measure than a widely extended dissection in search of the bleeding point.

1. **Ligature in the Upper Third of the Leg.** *Position.*—The patient lies upon the back. The limb is straight upon the table. The foot projects beyond the edge of the table, and is forcibly extended, and (with the leg) fully rotated inwards. The surgeon stands always to the outer side of the limb. The incision for the right artery is made from above down; for the left, from below up. Two assistants stand on the opposite side of the table—one steadies the leg and manipulates the foot, the other attends to the wound.

Operation.—Before anæsthetising the patient, the outer margin of the tibialis anticus should be, if possible, defined by causing the patient to contract the muscle.

An incision, three and a half inches in length, is made precisely along the line of the artery (Fig. 332). Its upper end will be about one inch below the head of the tibia. The deep fascia is exposed, and is divided along the same line. The interval between the tibialis anticus and extensor communis digitorum is made out. The foot is now flexed to relax these muscles. The space between them is opened up by means of the finger and handle of the scalpel. In doing this, the external border of the tibia is aimed for, and should be distinctly felt before the artery is sought. In proceeding towards this border the extensor communis is held down by the first two fingers of the left hand, while the assistant holds the tibialis anticus towards the tibia with a re-

tractor. The outer border of the tibia having been made out with the forefinger, the artery will be found to the outer side of it, lying on the interosseous membrane. It is covered and held down by a moderately dense connective tissue. The artery is now exposed, a second retractor being used to repress the extensor communis (Fig. 333).

The venæ comites lie so close to the artery, and in such a position (Fig. 333), and send so many transverse branches across it, that it is practically impossible certainly to separate them. They will be probably enclosed in the ligature. The nerve lies to the outer side of the artery. The needle is passed from without inwards.

The nerve may not be seen. It may not join the artery until the middle third of the limb is reached. It, however, usually meets the vessel at the junction of the upper with the second fourth.

Comment.—The only difficulty in this operation is the finding of the gap between the tibialis anticus and the extensor communis digitorum. Not the least indication of it exists upon the surface of the deep fascia. The "white line" described by some authors is a myth, so far at least as this segment of the limb is concerned. On the other hand, there is a distinct septum between the extensor communis and the peroneus longus. This is indicated by a white line often marked by a deposit of fat, and also by the escape of cutaneous vessels. The fascia to the inner side of this line is dense, and is composed of oblique fibres all running downwards and inwards. This is the fascia covering the tibialis anticus and the common extensor. The fascia to the outer side of the line—that covering the peronei—is thinner, and made up mainly of longitudinal fibres crossed by a few transverse streaks.

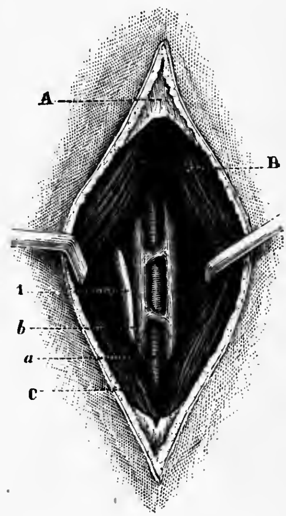

FIG. 333.—LIGATURE OF THE RIGHT ANTERIOR TIBIAL ARTERY (UPPER THIRD).

A, Fascia of leg; B, Tibialis anticus; C, Extensor communis digitorum; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

In seeking the proper muscular interval, the following points may be observed: Incise the fascia precisely in the "line of the artery." That line corresponds to the gap between the two muscles.

In a muscular subject the fascia may be divided by a second cut at right angles to the first. Bear in mind that the gap may not be evident even after a liberal turning back of the fascia. The fibres of the two muscles have the same direction, and the outer edge of the tibialis anticus may overlap the border of the extensor communis. There is usually a slight septum between the two muscles, but it is limited to the upper third of the limb, or even the upper fourth or upper sixth. From an operative point of view it is not to be relied upon. The gap required is to be felt rather than seen. No attempt should be made to demonstrate it by cutting. The forefinger and the handle of scalpel should alone be used. The gap lies about a finger's breadth from the septum between the extensor communis and the peroneus longus, and about an inch or an inch and a quarter from the tibial crest. It can be best made out by pressing the forefinger along the muscles lengthways, when it is appreciated as the line of least resistance.

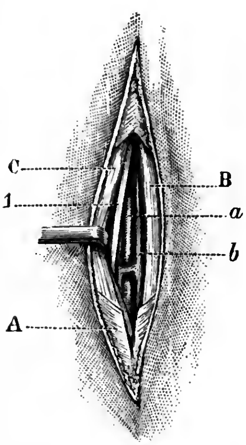

FIG. 334. — LIGATURE OF RIGHT ANTERIOR TIBIAL ARTERY (LOWER THIRD).

A, Anterior annular ligament; B, Tibialis anticus; C, Extensor proprius pollicis; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

2. **Ligature in the Middle Third of the Leg.** *Operation.*—The position is the same as in the above operation. Make an incision three inches in length along the line of the artery (Fig. 332). The deep fascia is exposed. The interval between the tibialis anticus and extensor communis is indicated by a yellowish white line. This is due, not to a distinct septum, but to a line of fatty tissue lodged between the two muscles. In emaciated subjects the line may not be apparent. The deep fascia is divided along this line. The two muscles above named are found lying close together. The outer edge of the tibialis anticus is still muscular, but the inner edge of the common extensor is now tendinous.

Flex the foot. Separate the muscles with the handle of the scalpel, keeping in the direction of the tibia. The artery is found upon the interosseous membrane, with the still deeply placed extensor pollicis to its outer side. The nerve will be exposed before the artery is reached, since it here usually lies in front of the vessel. The needle may be passed from either side. It may be impossible to separate the venæ comites, but great care must be taken to avoid the nerve. In the living

subject persistent attempts to separate the venæ comites will probably only lead to laceration of those vessels.

3. **Ligature in the Lower Third of the Leg.** *Operation.*—The position is the same, only the foot need not be so much rotated in.

An incision, two to two and a half inches in length, is made in the line of the artery, and just to the outer side of the tendon of the tibialis anticus.

The tendon must be identified beyond doubt before the operation is proceeded with. The deep fascia—here known as the upper band of the anterior annular ligament—is divided in the same line; and the space between the tibialis anticus tendon and the tendon of the extensor pollicis is defined. Both these tendons will be exposed. The artery lies between them, on the front of the tibia, and embedded in a considerable quantity of fatty connective tissue. The foot is a little flexed, the extensor pollicis tendon is drawn to the outer side by a small blunt hook, and the exposed artery is easily secured.

The nerve lies to the outer side, and the needle should be passed from the nerve. As the vessel is quite superficial, the venæ comites may be separated so as to make room for the needle (Fig. 334).

Comment.—The operation is without difficulty, if one tendon is not mistaken for another. The nerve may lie in front of the artery. The two malleolar arteries—vessels about the size of the posterior auricular—come off just above the ankle-joint.

There are these objections to the operation in this situation: the upper band of the annular ligament is divided, and the synovial sheath of the tibialis anticus will almost certainly be opened. This is the only synovial sheath on the front of the limb at this level.

Collateral Circulation after Ligature of the Anterior Tibial Artery.

External malleolar with anterior peroneal and calcaneal of posterior peroneal.
Internal malleolar with internal malleolar of posterior tibial.

Dorsal pedis and its branches	with	Internal plantar. External plantar. Anterior peroneal. Calcaneal of posterior peroneal.

Muscular branches from anterior and posterior tibial which anastomose after piercing the interosseous membrane.

Varieties of the Anterior Tibial Artery.

1. The vessel may be wanting, its place being supplied by perforating branches from the posterior tibial.
2. It may incline outwards towards the fibula at the lower

part of the leg, and then return to its ordinary position on the dorsum of the foot.

3. It may become superficial about the middle of the leg, and run the rest of its course covered only by the fascia and the skin.

THE POSTERIOR TIBIAL ARTERY

Anatomy (Plate XXII.).—The vessel lies betwen the superficial and the deep muscles of the calf, and is closely bound to those of the latter group by the deep fascia which covers them. At its origin at the lower border of the popliteus muscle, the artery is opposite the interval between the tibia and fibula. It arises on a level with the lower part of the tubercle of the tibia and about two inches below the knee-joint. It divides at the lower border of the inner annular ligament, on a level with a line drawn from the tip of the malleolus to the centre of the convexity of the heel.

The upper part of the artery is very deeply placed beneath the gastrocnemius and soleus muscles. In the lower third of the leg the vessel is superficial, being covered only by the skin and the fascia. It lies successively on the tibialis posticus, the flexor longus digitorum, the tibia and the ankle-joint. There are two venæ comites, which lie one on either side of the artery. The posterior tibial nerve lies at first on the inner side of the artery. It crosses the vessel about one inch below the lower border of the popliteus muscle, and runs for the rest of its course to the outer side of the artery.

Line of the Artery.—A line drawn from the centre of the ham to a point midway between the inner malleolus and the heel will correspond to about the lower half of the artery. The upper half forms a slight curve inward from this line.

Indications.—The artery may be tied in the leg or behind the ankle. It is usually secured for wound. The vessel may be ligatured at its lower end in some cases of wound of the sole.

In some punctured wounds of the thick part of the calf doubts may exist as to which of the deep vessels is wounded. In such a case elevation of the limb, with pressure, followed possibly by the proximal ligature, may be a better mode of treatment than an extensive dissection of a muscular limb in search of the bleeding point. Laceration of this artery associated with fracture of the bone has been successfully treated by ligature in Hunter's canal.

Aneurysm is more common in the posterior than in the anterior tibial. Kinloch had tabulated twenty-two examples of spontaneous aneurysm in 1882. The tumour usually occupies the upper half of

FIG. 1.—SECTION OF RIGHT LEG ABOUT ITS MIDDLE.

1, TIBIALIS ANTICUS MUSCLE 2, EXTENSOR DIGITORUM. 3, EXTENSOR LONGUS HALLUCIS. 4, TIBIALIS POSTICUS. 5, PERONEI MUSCLES. 6, FLEXOR LONGUS HALLUCIS. 7, 8, 10, SOLEUS. 9, FLEXOR LONGUS DIGITORUM. 11, GASTROCNEMIUS. 12, MUSCULO-CUTANEOUS NERVE. 13, ANTERIOR TIBIAL NERVE. 14, POSTERIOR TIBIAL NERVE. 15, INTERNAL SAPHENOUS NERVE. 16, SHORT SAPHENOUS NERVE. 17, COMMUNICANS PERONEI NERVE. 18, POSTERIOR TIBIAL ARTERY. 19, ANTERIOR TIBIAL ARTERY. 20, PERONEAL ARTERY AND VEINS.

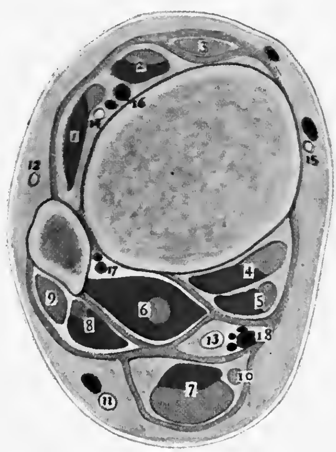

FIG. 2.—SECTION OF THE LEG JUST ABOVE THE ANKLE-JOINT.

1, EXTERIOR COMMUNIS DIGITORUM. 2, EXTENSOR LONGUS POLLICIS. 3, TIBIALIS ANTICUS (IN SEPARATE SHEATH). 4, TIBIALIS POSTICUS. 5, FLEXOR COMMUNIS DIGITORUM. 6, FLEXOR LONGUS POLLICIS. 7, TENDO ACHILLIS. 8 AND 9, PERONEUS LONGUS AND BREVIS. 10, PLANTARIS 11, EXTERNAL SAPHENOUS VEIN. 12, EXTERNAL SAPHENOUS NERVE. 13, POSTERIOR TIBIAL NERVE. 14, ANTERIOR TIBIAL NERVE. 15, INTERNAL SAPHENOUS NERVE AND VEIN. 16, ANTERIOR TIBIAL ARTERY. 17, PERONEAL ARTERY. 18, POSTERIOR TIBIAL ARTERY.

PLATE XXII.—TRANSVERSE SECTIONS OF THE LEG.

the leg. When Esmarch's bandage, acute flexion of the knee, and compression of the femoral have failed, the artery has been secured with success above the aneurysm, provided the latter has been placed low enough down.

1. **Ligature behind the Malleolus.** *Position.*—The patient lies on the back. The knee is flexed, and the leg lies upon its outer side. The foot lies upon the table, also on its outer side, and is secured in that posture by an assistant. The surgeon stands to the outer side of the limb in either instance (right or left limb).

Operation.—A curved incision, two inches in length, is made about half an inch behind and parallel with the margin of the inner malleolus (Fig. 335). The knife is directed towards the tibia. The internal annular ligament is exposed, and divided over the artery. The vessels and the nerve lie in a gap between the tendons that can be appreciated by the touch. The artery having been exposed and separated from the veins, the needle is passed from without inwards.

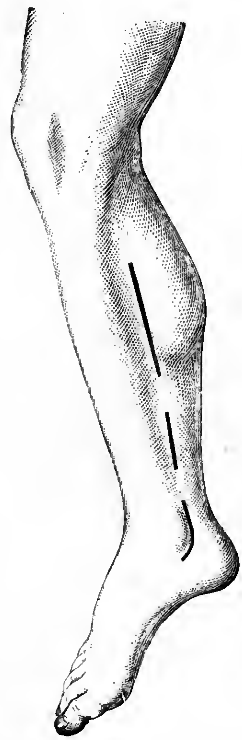

FIG. 335.—LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY.

Comment.—If the veins are very closely applied about the artery, they may be included in the ligature. In case of high division of the trunk, two vessels will appear, and both will require to be secured. Care must be taken not to open the sheaths of the adjacent tendons. The first canal in the annular ligament (that nearest to the malleolus) contains the tibialis posticus tendon; the second contains the tendon of the flexor longus digitorum. Each of these canals has a separate synovial lining. Then follows a space wider than that for either of the two named canals, in which are lodged the vessels and nerve. A fourth canal on the astragalus, lined also by a synovial membrane, transmits the flexor longus hallucis pollicis tendon.

2. **Ligature at the Lower Third of the Leg.** *Operation.*—The position is the same as in the previous operation. An incision, two inches in length, is made along the line of the artery,

midway between the margin of the tendo Achillis and the inner edge of the tibia (Fig. 335). The superficial and deep fascia are divided, together with the upper part of the inner annular ligament. The artery is found lying on the flexor longus digitorum muscle, with the nerve to its outer side. The needle is passed from the nerve. The venæ comites will have to be included if they cannot be readily separated from the artery (Fig. 336).

Comment.—The flexor longus digitorum contains fleshy fibres until the malleolus is reached. The vessel lies upon the fleshy part, and to the outer side of the tendon.

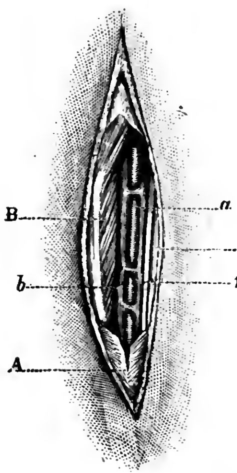

FIG. 336. — LIGATURE OF RIGHT POSTERIOR TIBIAL ARTERY (LOWER THIRD).

A, Fascia of leg (internal annular ligament); B, Flexor longus digitorum and tendon; C, Tendo Achillis; *a*, Posterior tibial artery; *b*, Posterior tibial vein; 1, Posterior tibial nerve.

The communicating branch between the posterior tibial and peroneal arteries arises an inch above the ankle-joint. The ligature will be placed above this branch.

3. **Ligature in the Middle of the Calf.** *Operation.*—The position is the same as in the preceding operations. The calf of the leg rests upon the table on its outer side, and the surgeon leans over the limb. The incision is made from above downwards on the right side, and from below up on the left. The assistant, armed with retractors, stands on the opposite side of the table.

An incision, four inches in length, is made in the middle third of the leg, parallel to the inner margin of the tibia and three-quarters of an inch behind that crest of bone (Fig. 335). The skin having been divided, care must be taken not to wound the internal saphenous vein, which should be drawn aside. The deep fascia—the fibres of which are all transverse—is exposed and divided. In a muscular subject the margin of the gastrocnemius may be seen.

The soleus is now exposed, and must be divided through the length of the incision. The aponeurosis of the muscle is cut through, together with the fleshy fibres attached to it. In making this section the knife should be kept perpendicular to the surface of the muscle. Its edge will therefore be directed towards the tibia, and its blade—in the position in which the limb is held—will be nearly horizontal (Fig. 337). When the muscle has been divided, the outer part must be drawn

well outwards by a broad retractor or retractors held by an assistant. The deep fascia that covers in the vessels and the deep muscles of the leg is now exposed. If the finger be introduced the vessel can be felt. It must be remembered that the artery lies near the outer border of the tibia. When the fascia has been divided (it is usually very thin) the fleshy fibres of the flexor longus digitorum are exposed. These fibres all run obliquely downwards. By following the surface of the muscle the vessels are reached. The veins are very conspicuous, and may hide the artery. The nerve lies to the outer side, and the needle should be passed from the nerve. It is practically impossible to separate the venæ comites from the vessel.

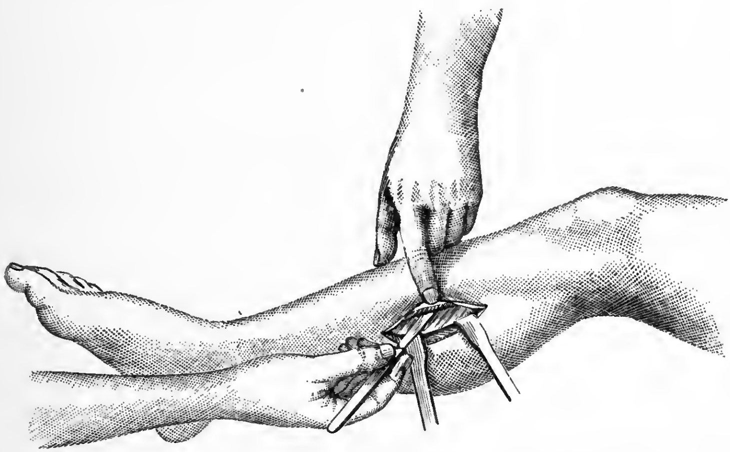

FIG. 337.—MODE OF DIVIDING THE SOLEUS MUSCLE IN LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY IN THE MIDDLE OF THE CALF. (*After Farabeuf.*)

Comment.—This operation requires a good light, and may be most conveniently done with the aid of a small electric lamp.

The tissues must be carefully retracted, and all the soft parts drawn outwards. In using the retractors roughly, some fibres of the flexor longus digitorum may be torn up and made to hide the artery. This may readily occur in the cadaver. If in dividing the soleus the knife be not kept towards the tibia, a too extensive division of muscle results, and the wound is unnecessarily deepened.

If the section of this muscle is made too close to the tibia, it is very easy to get the retractor beneath the flexor digitorum, and the surgeon dissecting on beneath that muscle may find himself at the interosseous membrane. The soleus at the point of section is—in a fairly developed subject—somewhat thicker than the little finger. The

lateral tendinous intersection in the substance of the muscle may be encountered and divided. In identifying muscle it should be remembered that the fibres of the soleus in this situation are attached only along the narrow line formed by the inner margin of the tibia. The surgeon should not lose sight of the fact that the part for which he is aiming is in a line with the outer margin of the tibia.

Collateral Circulation after Ligature of the Posterior Tibial Artery.

Peroneal	with	Posterior tibial by communicating branch and by muscular branches.
External calcaneal of peroneal	with	Internal calcaneal of external plantar.
External malleolar	with	External plantar.
Internal malleolar of anterior tibial	with	Internal malleolar of posterior tibial.
Dorsalis pedis and its branches	with	Internal and external plantar.

Varieties of the Posterior Tibial Artery.

1. The artery may be very small at its commencement, and be reinforced lower down by transverse branches from the peroneal.
2. It may be wanting, and be replaced by the peroneal.
3. It may be covered in the lower third of the leg by muscle which may represent an accessory long flexor of the toes or a slip of the soleus (Quain).

THE POPLITEAL ARTERY

Anatomy.—The vessel extends from the opening in the adductor magnus to the lower border of the popliteus muscle, passing through the centre of the popliteal space. From its commencement to a point behind the middle of the knee-joint the artery inclines from within outwards; beyond this point it descends vertically. The artery is deeply placed. Its upper end is covered by the semi-membranous muscle, its lower end by the gastrocnemius. Between these points it lies deeply in the popliteal space. The popliteal vein lies close to the artery. It is placed at first to the outer side, and a little behind the artery; it then gradually crosses over that vessel, and ultimately gains its inner side. This vein is remarkably substantial, and has walls so thick and dense that in section they look not unlike the tunics of an artery. It is, moreover, very closely

adherent to the artery. It may be double along the lower part of its course.

The internal popliteal nerve is at first to the outer side of the artery and superficial to it. It then crosses gradually over the vessels, and lies behind and to the inner side of them, below the joint. The nerve is throughout separated from the artery by the vein. In the centre of the ham the nerve and vein lie exactly over the artery.

The crease in the skin which crosses the popliteal space transversely is some way above the line of the knee-joint.

The guide to the upper part of the artery is the outer border of the semi-membranosus. The popliteal ends on a level with the lower part of the tubercle of the tibia.

Indications.—The popliteal artery is but rarely tied in comparison with the superficial femoral. At the middle of its course it lies so deeply in the popliteal space, and is so closely covered by the popliteal vein, that even as a dissecting-room operation its ligature here has little to recommend it. At the upper and lower ends of the space, however, the artery is more accessible. The bend of the knee is a frequent site for aneurysm, which is as a rule most successfully treated by ligature of the femoral in Hunter's canal or at the apex of Scarpa's triangle. In certain cases this proximal ligature alone has failed to cure, and then excision of the aneurysmal sac through a median incision in the popliteal space, combined with ligature of the vessel above and below, has been carried out, with favourable results. Out of sixteen cases operated on in this manner (quoted by Walsham, *Med.-Chir. Trans.*, 1899, page 223) the operation failed in only two—viz. in one from gangrene of the limb, and fatal erysipelas in the other. It may be said that fifteen out of sixteen cases recovered, or ought to have done so. This operation has been rendered feasible and fairly safe by the introduction of Esmarch's tourniquet, which should be applied after the limb has been kept elevated, and digital pressure made on the femoral for some little time. In dissecting out the sac great care should be taken to avoid injuring the popliteal nerves, and, if possible, the popliteal vein should also be spared, although its adhesion to the sac has rendered its ligature necessary in several cases. It is urged by some that extirpation of the aneurysm from the popliteal space

should be performed in ordinary cases in preference to ligature in the thigh, the chief reason assigned being that after the latter operation the shrinking of the sac causes painful contraction of the knee. There is but little evidence in favour of this assertion, and as a rule proximal ligature without excision should undoubtedly be performed.

It is appropriate here to refer briefly to a novel proposal for obliteration of an aneurysm by sutures, a method introduced by Dr. Matas. Elaborate descriptions and figures to illustrate this method are given in the *Annals of Surgery*, February, 1903. The idea is to sew up, by means of continuous or interrupted sutures of very fine silk, the orifice between the aneurysm and the artery on which it is situated. The operation is carried out with Esmarch's bandage applied to the limb. It would of course be quite impossible unless the part could be rendered bloodless, and the method is therefore limited to aneurysms in the limbs.

"The sac is not extirpated or interfered with, except so far as is needed to empty it and freely expose its interior; no ligatures are applied to the main artery, and the circulation in the sac is arrested and hæmorrhage prevented by suturing the arterial orifices found in the sac. The sac is obliterated by sutures which infold it, aided by plastic effusion from the intima."

The idea of obliterating the aneurysm whilst *leaving the main vessel still patent* is an attractive one, as the risk of gangrene inseparable from ligature of the artery would thereby be avoided. But it may be pointed out that no proof exists that it is possible to close the orifice between sac and artery by suture without causing ultimate obliteration of the latter. We cannot see, therefore, that anything is gained by the procedure. Further, an examination of most specimens of aneurysm on such arteries as the popliteal will show how irregular and extensive is the orifice of the sac, and how ill adapted for sewing up by fine silk threads.

Proximal ligature of the main vessel, as near to the aneurysm as practicable, is a sounder method of treatment, and experience has proved it to be most successful. We emphasise the advantage of placing the ligature near to the aneurysm, and the following case will illustrate the reason. In a patient with

popliteal aneurysm we tied the superficial femoral artery in Bunter's canal with kangaroo tendon. Perfect obliteration of the vessel at the site of ligature resulted (as proved in the subsequent operation), but at the end of three weeks the aneurysm began to pulsate and enlarge again, owing to free collateral circulation. Extirpation of the sac was then performed with success, but in the operation a part of the adherent popliteal vein had to be removed also.

Apart from aneurysm, the popliteal artery has been occasionally tied after a wound, and sometimes for that produced by the chisel in performing osteotomy.

1. **Ligature of the Lower Part of the Artery.** *Operation.*—The patient is so rolled over as to rest upon the shoulder and one side of the chest, and is indeed made to lie as nearly prone as the circumstances attending the administration of an anæsthetic will permit. The limb is fully extended. The surgeon will stand to the outer side of the left limb and to the inner side of the right. The chief assistant is placed opposite to him. In the case of either extremity the incision is made from above downwards.

A vertical incision—from three to three and a half inches in length—is made over the back of the limb, commencing opposite to the centre of the popliteal space (i.e. the level of the knee-joint), and extending downwards over the interval between the two heads of the gastrocnemius muscle.

The skin and superficial fascia having been divided, care must be taken not to damage the short saphenous vein and nerve. These structures will appear at the outer part of the wound, and should be drawn outwards. The deeper fascia is divided in the same vertical line.

The heads of the gastrocnemius muscle are now exposed, and the surgeon follows the interval between them. On each side of this gap a sural artery will be found, accompanied by the nerve to the corresponding head of the muscle.

Deep in the interval itself the large nerve to the soleus muscle (from the internal popliteal) will probably be met with, and must be drawn aside. It usually lies directly in the line of the operation.

Following the short saphenous vein, the surgeon is guided to

the popliteal vessels. This part of the operation is rendered easier by flexing the knee-joint a little so as to relax the gastrocnemius. The internal popliteal nerve is first encountered, then the vein and the artery. The two first-named structures are drawn to the inner side. The artery is cleared, and the needle is passed from the inner side (Fig. 338).

2. **Ligature of the Upper Part of the Artery.**—This operation—known as Jobert's operation for the ligature of the popliteal artery (*Nouvelle Bibliothèque Méd.*, February, 1827)—is carried out in the thigh. The vessel is secured close to the inner side of the femur, and is reached between the semi-membranosus muscle and the tendon of the adductor magnus.

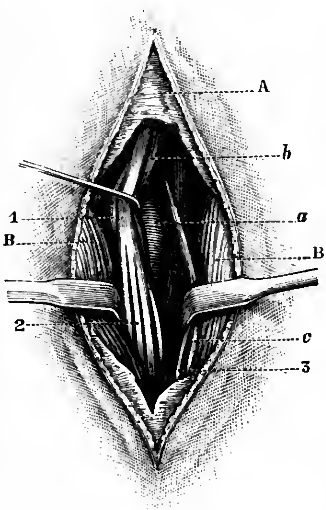

FIG. 338.—LIGATURE OF RIGHT POPLITEAL ARTERY (LOWER PART).

A, Fascia; B, Gastrocnemius; *a*, Popliteal artery; *b*, Popliteal vein; *c*, External saphenous vein; 1, Internal popliteal nerve; 2, Muscular branches; 3, External saphenous nerve.

Operation.—The patient lies upon the back, with the hip a little flexed and the thigh fully abducted and rotated outwards. The knee-joint is bent at a right angle, and the knee and leg are thus made to lie upon the outer side.

The surgeon stands to the outer side of the extremity in either case. The incision on the right side is made from above downwards, and on the left from below upwards. The chief assistant faces the operator.

The incision is three inches in length, is commenced at the junction of the middle and the lower thirds of the thigh, and is parallel with and just posterior to the tendon of the adductor magnus. The position of this tendon should have been well defined (Fig. 339).

After the skin has been divided there will probably be found in the subcutaneous fat the anterior division of the internal cutaneous nerve, which lies usually in the direct line of the operation. It should be drawn aside.

The anterior edge of the sartorius muscle is next exposed, and the whole muscle must be displaced backwards.

Upon this muscle at this point will lie the internal saphenous vein. The vessel may possibly be exposed, in which case it is drawn backwards with the sartorius.

The trunk of the internal saphenous nerve is not encountered. It lies beneath the sartorius.

The deep fascia having been well divided, the tendon of the adductor magnus is sought for, and is drawn forwards with a blunt hook. The semi-membranosus muscle is next exposed, and is drawn backwards with a retractor. The operator now seeks for the artery in the interval between the two structures. The vessel will be surrounded by much connective tissue, and is lying close to the bone. The internal popliteal nerve is here at some distance from the vessel, and will not be seen. The vein also is not necessarily exposed. It lies posteriorly to the artery, and to its outer side. Indeed, as approached from this point, the artery is the most superficial of the three structures named.

When the vessel has been properly exposed, the needle may be passed from below upwards.

An aneurysm-needle with a large lateral curve will be found the most convenient.

In performing this operation care must be taken not to wound the deep branch of the anastomotica magna artery, which runs along the anterior surface of the adductor magnus tendon.

Collateral Circulation after Ligature of the Popliteal Artery.—The inferior articular arteries, the anterior tibial recurrent (with possibly the posterior tibial recurrent and superior fibular branches of the anterior tibial), *below* the ligature, communicate with the superior articular arteries, the anastomotica magna and external circumflex arteries, *above* the ligature.

Muscular branches will also take part in establishing the new circulation.

Varieties of the Popliteal Artery.—This artery is very seldom found to deviate from the normal condition. The only variety which is at all common is the high division of the vessel into its terminal branches. Such division may take place opposite the knee-joint, or even behind the intercondyloid fossa of the femur.

THE FEMORAL ARTERY

Anatomy.—The diameter of the common femoral is from 9 to 10 mm., the superficial femoral is the size of the carotid artery and the profunda of the brachial.

At the groin the artery is in front of the summit of the head of the femur. At its lower end it lies close to the inner surface of the shaft of the femur. Between these points it is placed at some little distance from the bone.

The vessel lies, in order from above downwards, upon the psoas, pectineus, adductor brevis, adductor longus, and the tendon of the adductor magnus.

The femoral lies at first in Scarpa's triangle, where it is superficial. The apex of this triangle is from three to three and a half inches below Poupart's ligament.

The vessel then enters Hunter's canal, which occupies the middle third of the thigh.

In this canal are the artery and vein, the internal saphenous nerve, and the superficial part of the anastomotica magna artery.

The profunda femoris arises one inch and a half below Poupart's ligament, and the two circumflex arteries some two inches below that structure.

At the groin the femoral vein is upon the same plane as the artery, and to its inner side. At the apex of Scarpa's triangle the vein is behind the artery. In Hunter's canal it lies behind and a little to the outer side. The vein is throughout very close to the artery.

At the apex of Scarpa's triangle both the femoral and the profunda veins separate the two corresponding arteries, the order from before backwards being—the femoral artery, the femoral vein, the profunda vein, the profunda artery.

The anterior crural nerve lies well to the other side of the artery at the groin. The internal cutaneous nerve crosses the vessel at the upper edge of the sartorius. The internal saphenous nerve comes in front of the artery just above the middle of the thigh, and lies in front, and a little to the outer side of it, in Hunter's canal.

The course of the long saphenous vein may be roughly represented by a line drawn from a point about three-quarters

of an inch to the inner side of the line of the femoral artery at the groin, to the posterior border of the sartorius muscle at the level of the condyle of the femur.

Line of the Artery.—The hip being a little flexed and the thigh abducted and rotated outwards, a line is drawn from a point midway between the anterior superior spine of the ilium and the symphysis pubis, to the tuberosity of the internal condyle (Fig. 339). The centre of Poupart's ligament is entirely to the outer side of the line of the vessels.

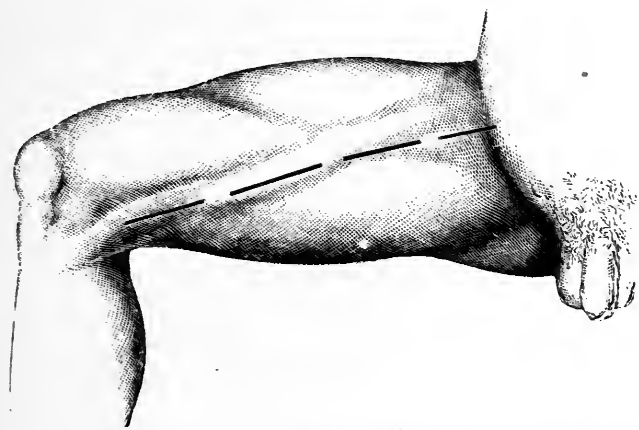

FIG. 339.—LIGATURE OF THE RIGHT COMMON FEMORAL AT THE BASE OF SCARPA'S TRIANGLE; OF THE FEMORAL AT THE APEX OF SCARPA'S TRIANGLE AND IN HUNTER'S CANAL; AND OF THE UPPER PART OF THE POPLITEAL.

Indications.—The superficial femoral may be ligatured in Hunter's canal or at the apex of Scarpa's triangle. The common femoral may be ligatured at the base of that triangle.

The only one of these three operations which is performed with any degree of frequency is the ligature at the apex of Scarpa's triangle. This is called the "place of election," and in any case in which "ligature of the femoral" is advised or is mentioned, it is assumed that the vessel is secured at this point.

A ligature may be applied here in certain cases of popliteal and lower femoral aneurysm which have resisted simpler treatment, and in certain cases of wound and of arterio-venous aneurysm.

The femoral has been tied at this point also for the relief of elephantiasis Arabum.

A ligature is very rarely indeed applied to the common femoral. Great risks attend the procedure, although they have been minimised by the teaching of antiseptic surgery. The risk of gangrene is considerable, as is also that of secondary hæmorrhage. The operation has proved to be more dangerous when the vessel is secured between the deep epigastric and profunda arteries than when it is ligatured either above or below those branches.

The numerous small vessels which arise from the common femoral, the proximity of the profunda, and the occasional high origin of that vessel or of one of the circumflex arteries, render a sound occlusion of the main artery a matter of uncertainty. In most of the circumstances in which a ligature of the common femoral might be suggested, the securing of the external iliac artery is the better procedure in actual practice.

The common femoral is secured as a preliminary measure in some amputations at the hip-joint, and in certain cases of wound.

The ligature in Hunter's canal has been employed in cases of wound, in some exceptional examples of aneurysm, in arterio-venous aneurysms, and in bleeding from the stump after amputation through the lower part of the thigh. John Hunter was the first surgeon to apply a ligature to this part of the artery for popliteal aneurysm. The operation was performed in 1785.

Position.—The patient lies upon the back, with the hip a little flexed, with the thigh abducted and rotated outwards, with the knee bent and the leg resting upon its external surface.

The surgeon stands to the outer side of the limb in either case, and the chief assistant is placed opposite to him. The incision —in the case of the right thigh—is made from above downwards, and in the case of the left from below upwards.

1. **Ligature of the Superficial Femoral in Hunter's Canal.** *Operation.*—The limb having been placed as already indicated, an incision about three inches in length is made along the line of the artery in the middle third of the thigh (Fig. 339).

In the layer of subcutaneous tissue the anterior division of the internal cutaneous nerve will probably be met with, and to

the inner side of it the long saphenous vein. This vessel must be drawn inwards.

The fascia lata is now divided in the line of the original wound, and the sartorius is exposed. This muscle must be clearly identified. Its fibres run downwards and inwards.

The anterior or outer edge of the muscle having been exposed, the whole structure is drawn inwards with a suitable retractor.

The site of Hunter's canal, lying between the adductor magnus and the vastus internus, can now be well defined, especially if the fibres of the great adductor and the lower border of the adductor longus are made prominent by fully abducting the thigh.

When any fatty tissue which may obscure the part has been cleared away, the fascia which forms the roof of Hunter's canal is rendered distinct. The fibres forming this fascia are arranged transversely.

At this point there may be exposed, at the outer side of the wound, the nerve to the vastus internus.

The canal is opened in the line of the original wound, and the artery exposed (Fig. 340).

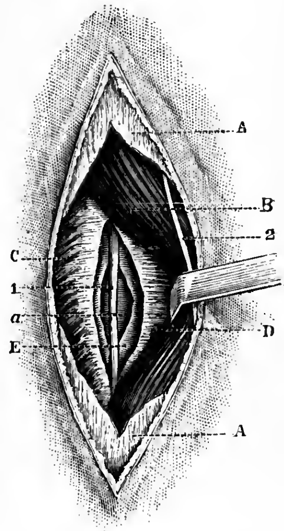

FIG. 340.—LIGATURE OF RIGHT SUPERFICIAL FEMORAL ARTERY IN HUNTER'S CANAL.

A, Fascia lata; B, Sartorius; C, Vastus internus; D, Fascia closing in Hunter's canal; E, Sheath of artery; *a*, Femoral artery; 1, Long saphenous nerve; 2, Anterior branch of internal cutaneous nerve.

The needle may be passed from either side.

In front and to the outer side of the vessel will be found the internal saphenous nerve, which is easily avoided.

Care must be taken that the vein be not damaged in passing the needle round the artery.

Comment.—The cut is apt to be made too far outwards, in which case the vastus internus is exposed instead of the sartorius, and the one muscle may be mistaken for the other. Their fibres, however, run in opposite directions, those of the vastus downwards and outwards, those of the sartorius downwards and inwards.

The incision may be made too low down, and the popliteal artery be reached.

In making the skin wound carelessly the internal saphenous vein has been cut into.

The whitish tendon of the adductor magnus has been mistaken for the artery in the dead subject.

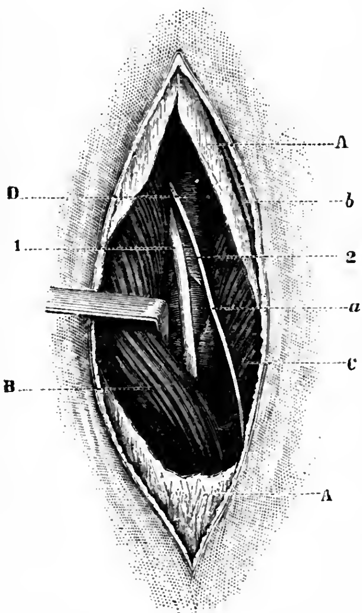

FIG. 341.—LIGATURE OF RIGHT SUPERFICIAL FEMORAL ARTERY AT APEX OF SCARPA'S TRIANGLE.

A, Fascia lata; B, Sartorius; C, Adductor longus; D, Sheath of artery; *a*, Femoral artery; *b*, Tributary of internal saphenous vein; 1, Long saphenous nerve; 2, Internal cutaneous nerve.

Farabeuf recommends that as soon as the sartorius muscle has been drawn aside, the thigh should be well abducted and rotated out, so as to bring into prominence a tendinous cord—*la corde qui vibre*—which is derived from the lower fibres of the adductor longus, and is passing to the general adductor insertion. This cord helps to define the canal, and the incision is made first to its outer side.

2. **Ligature of the Superficial Femoral at the Apex of Scarpa's Triangle.** *Operation.*—The limb is placed in the position already indicated, and the line of the artery is marked out.

An incision, three inches in length, is made along this line as it crosses the apex of Scarpa's triangle. The centre of the wound should correspond to the apex, and the incision, therefore, will reach to within one and a half or two inches of Poupart's ligament (Fig. 339).

A large tributary of the internal saphenous vein will usually be exposed, and if it cannot be drawn easily aside it should be divided between two ligatures.

The fascia lata having been divided in the original line, the sartorius is exposed at the outer part and inferior end of the wound, its fibres running downwards and inwards.

Its inner border should be well isolated, and the whole muscle is then drawn outwards.

The operator now feels for the groove of the artery. In front of the vessel will be found branches of the internal cutaneous nerve, and deeper and to its outer side are the long saphenous nerve, and, possibly, the nerve to the vastus internus (Fig. 341).

The sheath of the vessel should be well opened, and the needle passed from the inner side.

Comment. — Scarpa's triangle is much smaller than would appear to be the case when the dissected region is inspected. There may be no more than two inches of the artery left uncovered by the sartorius muscle. An unusually broad sartorius adds a little to the difficulty of the operation.

In order to reach the edge of the sartorius muscle easily, the cut is often made too much to the inner side, with the result that the great saphenous vein is cut into. On the other hand, if the thigh be not placed in proper position, the incision is apt to fall too much to the outer side.

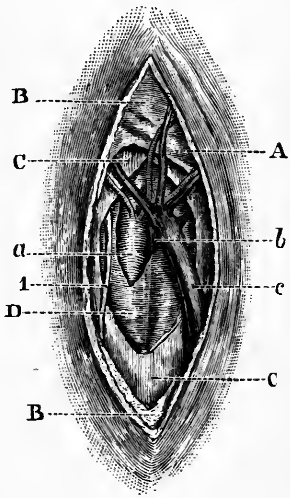

FIG. 342.—LIGATURE OF RIGHT COMMON FEMORAL ARTERY AT BASE OF SCARPA'S TRIANGLE.

A, Line of Poupart's ligament; B, Superficial fascia; C, Fascia lata; D, Sheath; *a*, Femoral artery; *b*, Femoral vein; *c*, Internal saphenous vein; 1, Genito-crural nerve.

The special danger of the operation consists in the wounding of the vein in passing the needle. The greatest care must be taken to open the sheath of the artery well, and to keep the point of the needle close to the arterial wall.

An aneurysm-needle, curved laterally, will usually be found the more convenient.

3. **Ligature of the Common Femoral at the Base of Scarpa's Triangle.** *Operation.*—The position of the surgeon and of the patient has been already indicated. An incision two inches in length is commenced a little above Poupart's ligament, i.e. on the abdomen, and is carried downwards parallel with the line of the artery (Fig. 339).

In dividing the layer of fatty tissue which covers the fascia lata, care must be taken not to injure any of the lymphatic glands of the region, and to avoid the superficial veins, notably the superficial epigastric and superficial circumflex iliac. The cribriform fascia is now divided in the original line, and especial care must be taken not to wound the superficial arteries, the two which usually come nearest to the incision being the superior external pudic and the superficial epigastric.

The crural branch of the genito-crural nerve lies upon the sheath of the artery, but upon the outer side of the vessel.

The sheath being clearly exposed and carefully opened, the needle is passed from the inner side (Fig. 342).

Comment.—By starting from the level of the centre of Poupart's ligament, the incision is placed to the outer side of the line of the vessels, and the vein is thus more certainly avoided. When the vein is at all distended, it is apt to overlap the artery.

Collateral Circulation after Ligature of the Femoral Artery.

(*a*) *After Ligature of the Common Femoral:*

Above.		*Below.*
Internal pudic	with	Pudic of femoral.
Gluteal	with	External circumflex, internal circumflex, and first perforating.
Circumflex iliac	with	External circumflex.
Obturator	with	Internal circumflex.
Sciatic	with	Superior perforating and internal circumflex.
Comes nervi ischiadici	with	Perforating.

(*b*) *After Ligature of the Superficial Femoral:*

Above.		*Below.*
External circumflex	with	Lower muscular branches of femoral, anastomotica magna, and superior articular branches of popliteal.
Perforating arteries and termination of profunda	with	Muscular branches of the femoral and popliteal and the superior articular arteries.

A communication is effected along the back of the thigh, between the sciatic artery, the terminal branches of the internal circumflex, the perforating arteries, and the branches of the popliteal. "In several instances in which the condition of the vessels has been examined after ligature of the femoral (or external iliac) artery,

the comes nervi ischiadici has been found much enlarged, forming, with anastomotic branches from the perforating arteries, a vessel which accompanies the great sciatic nerve, and ends below in the popliteal artery, or one of its branches." (*Quain.*)

Varieties of the Femoral Artery.—1. The femoral may divide below the origin of the profunda into two vessels, which reunite again at a variable distance above the opening in the adductor magnus to form a single popliteal artery.

2. A vas aberrans may leave the external iliac artery, and, running by the inner side of the common femoral artery, may join the superficial femoral about the apex of Scarpa's triangle.

3. The main artery of the limb may be found wholly at the back of the thigh, and be derived from a greatly enlarged sciatic artery.

4. The profunda may arise from the inner or from the posterior side of the main vessel, and may take origin less than one inch or more than two inches below Poupart's ligament.

5. The circumflex arteries may arise in whole or in part from the femoral. This especially applies to the internal circumflex.

6. The femoral may give off the deep epigastric, the circumflex iliac, or the great saphenous artery. The last-named vessel arises above or below the origin of the profunda, and passing along Hunter's canal, becomes superficial at the inner side of the knee, and follows the internal saphenous vein to the ankle.

The first three of these variations are so rare as to be of little or no practical importance.

CHAPTER V

LIGATURE OF THE ARTERIES OF THE LOWER LIMB AND THE ABDOMEN (*Concluded*)

The External Iliac Artery

Anatomy.—This vessel extends from the bifurcation of the common iliac, at the lumbo-sacral articulation, to Poupart's ligament, measures from three and a half to four inches in length, and has a diameter of from 9 to 10 mm.

The artery lies upon the iliac fascia, with which it is connected by a thin sheath derived from the subperitoneal tissue. It runs along the inner margin of the psoas muscle, and at Poupart's ligament is placed actually upon that muscle.

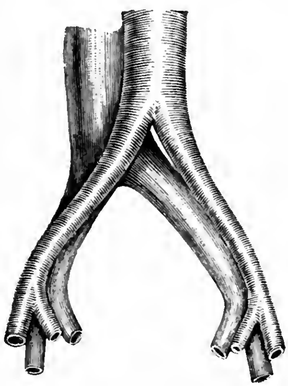

FIG. 343.—RELATION OF VEINS TO THE COMMON ILIAC ARTERIES.

It is covered by peritoneum. The sigmoid flexure crosses it on the left side, and the terminal part of the ileum on the right. The ureter passes over the vessel at the point of bifurcation of the common iliac.

About three-quarters of an inch above Poupart's ligament the artery is crossed by the circumflex iliac vein (represented at this point by a single trunk).

Passing over the lower part of the artery are the spermatic vessels and the vas deferens, which latter curves round the deep epigastric artery.

The genital branch of the genito-crural nerve lies upon the artery at its outer side. Some lymphatic glands and not a few lymphatic vessels lie upon or about the vessel.

The deep epigastric artery arises about one-fourth of an

inch above Poupart's ligament, and runs between the transversalis fascia and the peritoneum, in the direction of the umbilicus. The deep circumflex iliac artery comes off usually below the epigastric, and runs outwards behind Poupart's ligament, and rests upon the iliacus muscle.

The external iliac vein is at first behind the artery, and a little to the inner side. It ultimately is found upon the same plane as the artery, and entirely to the inner side (Fig. 343).

The internal abdominal ring is situated about half an inch above Poupart's ligament, opposite a point midway between the anterior-superior spine of the ilium and the symphysis pubis.

Line of the Artery.—A line drawn on the surface of the abdomen from a spot about a finger's breadth to the left of and below the navel, to a point midway between the anterior superior iliac spine and the symphysis pubis. The upper third of this line represents the common iliac, the lower two-thirds the external iliac (Fig. 344).

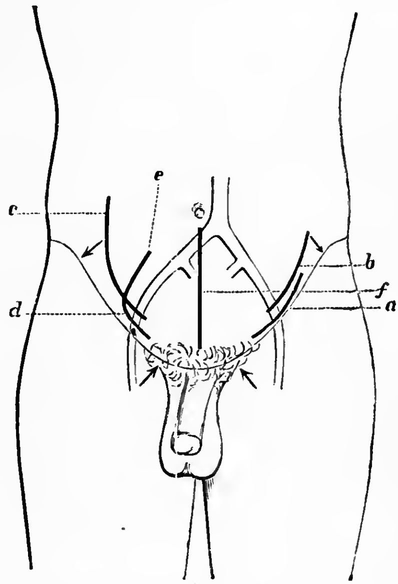

FIG. 344.—LIGATURE OF EXTERNAL ILIAC ARTERY.

a, Cooper's method (modified); *b*, Abernethy's method (modified). The arrows point to the anterior superior spines and the spines of the pubes.

LIGATURE OF COMMON ILIAC ARTERY.

c, Mott's method (modified); *d*, Marcellin Duval's operation; *e*, Point 1¼ inch to the outer side of the umbilicus; *f*, Ligature of the common or the internal iliac artery (intraperitoneal operation).

Indications.—The artery has been secured in cases of wounds and of secondary hæmorrhage, and for the treatment of aneurysms of various kinds in the upper part of the thigh.

It has been ligatured also to arrest the progress of malignant growths, and to modify the condition of the limb in elephantiasis Arabum. In neither case have the results been encouraging, the effect of the ligature being only temporary and slight.

In cases of aneurysm in the groin, ligature of the artery above should be resorted to, if possible, without trying digital or other pressure. The latter mode of treatment is rarely successful, and appears to make subsequent ligature more risky.

So far as the mortality of the actual operation is concerned, the procedure may be regarded as a successful one, 169 recorded cases having given in all but 61 deaths (Lidell). Many of these cases, however, belong to the days before antiseptic surgery. The chief danger arises from gangrene of the lower limb, and in the case of aneurysm from that strange and almost inexplicable accident, suppuration of the sac and its contained blood-clot.

As regards the risk of gangrene from obliteration of the external iliac, it is certainly small if the patient be comparatively young, and his blood-vessels generally healthy; it would be great in an individual with widespread ætheroma. Of course, gangrene of the limb will require amputation, and from this many of the recorded deaths have followed. The risk of gangrene from ligature of the external iliac seems to be actually less than from ligature of the common femoral lower down, a surgical paradox which is explained by the different conditions as to collateral circulation.

The vessel was ligatured for the first time in 1796 by Abernethy for inguinal aneurysm. His first two patients died, but the third and fourth recovered. (*Medical and Physical Journal,* 1802, page 97; and "Surgical Works," vol. i.)

Methods of Approaching the Artery.—The iliac arteries, including the external iliac, can be approached in one of two ways: 1, By opening the abdomen and by directly exposing the vessel. This is called the intraperitoneal method. 2, By means of a lateral incision, which divides all the structures of the abdominal wall with the exception of the peritoneum. The peritoneum is pushed aside, and the artery is reached without opening the serous cavity. This is called the extraperitoneal method.

Of these two methods, the former or intraperitoneal plan is undoubtedly the better in dealing with the common or the internal iliac artery. In ligaturing the external iliac vessel, the two methods are of about equal value, the balance, if any, being in favour of the extraperitoneal measure.

It must be remembered that before the introduction of aseptic surgery the iliac vessels were reached only by the extra-peritoneal method, and the operations which followed that method were the only ones known to surgeons. The opening of the serous membrane would have been followed, almost with certainty, by peritonitis, and that peritonitis was in pre-aseptic days very usually fatal. It is only since the introduction of asepsis that the surgeon has been able to disregard the peritoneum and to approach the iliac vessels by cutting into the abdomen and exposing them by a direct route.

I. THE OLD OR EXTRAPERITONEAL METHOD

Preparation and Position of the Patient.—The bowels should have been well evacuated, and if there be much flatulent distension of the abdomen, the operation, if not urgent, should be postponed until such complication has been dealt with. The pubic hair should be shaved when the skin is being prepared.

The patient lies upon the back, with the thighs extended and close together. The head and shoulders should be raised, in order to relax the abdominal parietes a little.

The surgeon stands to the outer side of the body in dealing with either artery, and cuts from above downwards on the right side, and from below upwards on the left. His face is towards the patient's face. The chief assistant is placed on the opposite side of the patient's body. To him is entrusted the responsible office of using the retractor.

A good broad retractor is needed, together with long dissecting forceps, and an aneurysm-needle with a lateral curve. A good light is essential. A reflector will be found convenient, but the most substantial aid is afforded by a portable electric lamp. With such a lamp as this the main difficulties of the operation are removed.

There are two principal methods of exposing the artery extraperitoneally, both of which have been modified beyond recognition, and which are known as Cooper's operation and Abernethy's method.

(1) **Sir Astley Cooper's Operation (Modified).**—The position of the patient has been already indicated. An incision, about

three inches in length, is made above Poupart's ligament. The cut is commenced about one inch to the outer side of the spine of the os pubis, and is placed half an inch above Poupart's ligament. For the inner two-thirds of its length it runs parallel with the ligament, but for the outer one-third it curves a little upwards away from the ligament. (Fig. 344, *a*.)

The skin and subcutaneous tissues are cut through, and in the latter will be divided the superficial epigastric artery and vein.

The white, glistening aponeurosis of the external oblique muscle is now exposed, and is divided in the line of the skin incision. The knife follows very nearly the direction of its fibres. The parts being retracted, the surgeon now seeks for the external border of the conjoined tendon, which will be made out at the inner end of the wound.

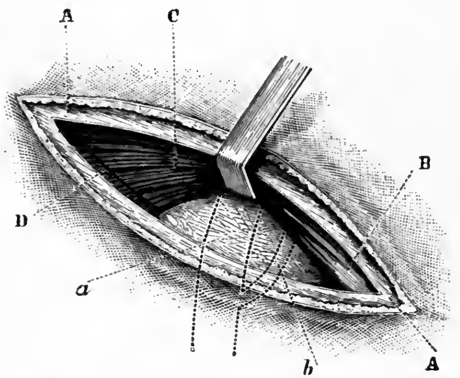

FIG. 345.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY.

(*Cooper's Method, modified.*)

A, Aponeurosis of external oblique; B, Conjoined tendon; C, Internal oblique; D, Line of incision in internal oblique muscle; *a*, Position of external iliac artery; *b*, Position of deep epigastric artery.

The lower fibres of the internal oblique muscle are drawn upwards (Fig. 345), and are divided close to their attachment to Poupart's ligament. The extent of the division corresponds to the extent of muscle tissue exposed in the wound. (The internal oblique is attached to the outer half or two-thirds of Poupart's ligament, the transversalis to the outer third only.)

The fascia transversalis is now exposed, and is divided transversely over the artery, and as far on either side of it as is necessary.

At this stage of the operation care must be taken not to wound the deep epigastric artery, which passes—between the transversalis fascia and the peritoneum—across the wound area.

The external iliac artery can now be made out. The sub-

peritoneal tissue about the vessels should be gently loosened, and the peritoneum then with the utmost care be peeled from the artery and vein, and pushed upwards in the direction of the umbilicus (Fig. 346).

The fingers alone should be employed in this process. Any form of director is unnecessary and dangerous.

The artery should be bared to such a height as to allow the ligature to be passed around it at a point one inch and a quarter above Poupart's ligament. The peritoneum must be kept out

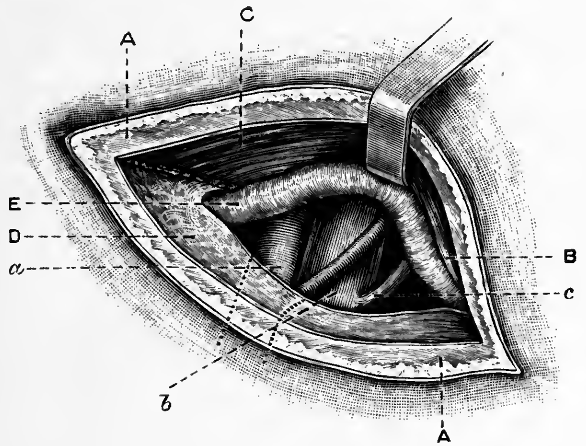

FIG. 346.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY.

(*Cooper's Method, modified.*)

A, Aponeurosis of external oblique; B, Conjoined tendon; C, Internal oblique; D, Transversalis fascia; E, Peritoneum; *a*, External iliac artery; *b*, External iliac vein; *c*, Deep epigastric vein.

of the way with the broad retractor while the artery is being exposed. The loose subperitoneal tissue which forms a kind of sheath for the artery should be cautiously cleared away. The needle is passed from within outwards.

After the ligature has been secured, the divided fibres of the internal oblique should be united to Poupart's ligament, and the rent in the external oblique aponeurosis be closed by a few points of buried suture of kangaroo tendon.

No drainage-tube is required.

Comment.—The wound must be of sufficient length, and be carefully placed.

If it be made too low down, there is danger of dividing the circumflex iliac vessels; if made too high up, of cutting into the internal abdominal ring. If it be carried too far outwards, an unnecessary amount of muscular tissue is divided; and if too far inwards, the external ring and the structures of the cord may be placed in jeopardy. With care, however, it is easy to displace the cord upwards, if necessary.

The tissues must be cleanly divided. The transversalis fascia should be cut sufficiently high to avoid the circumflex iliac vein, but not at too great a height.

Care should be taken not needlessly to tear up the sub-peritoneal fatty tissue, and not to wound the peritoneum. It should not be too extensively stripped up, and in clearing the article with the finger it is possible to detach the vessel from the psoas muscle. The vein has been damaged in passing the aneurysm-needle, and the genito-crural nerve has been included in the ligature.

The peritoneum has been not infrequently opened. This has resulted sometimes from too high an incision, because the serous membrane becomes more and more intimately connected with the transversalis fascia the farther the distance from Poupart's ligament. The peritoneal cavity has also been often opened up by the incautious use of the steel director (an instrument which should never be employed in this operation), and by a too free manipulation with the handle of the scalpel.

When proper asepsis is being observed, a wound of the peritoneum involves no extra risk. It is simply inconvenient, as it allows omentum or intestine to get in the way. Should the peritoneum be accidentally incised, the best course is to sew up the wound in it with a fine continuous catgut suture, then to push the peritoneal pouch upwards with finger or small sponge held in forceps, and to continue with the stages of the operation.

The artery should be secured at least one inch and a quarter above Poupart's ligament, in order that the ligature may be well clear of the large branches given off close to the ligament, and that a space be allowed for the formation of the necessary clot.

The deep epigastric artery has been accidentally cut during

the operation. This accident may cause much trouble, as both ends have to be secured.

(2) **Abernethy's Operation.**—Abernethy's original account is as follows:—"I first made an incision, about three inches in length, through the integuments of the abdomen, in the direction of the artery, and thus laid bare the aponeurosis of the external oblique muscle, which I next divided from its connection with Poupart's ligament, in the direction of the external wound, for the extent of about two inches. The margin of the internal oblique and transversalis muscles being thus exposed, I introduced my finger beneath them for the protection of the peritoneum, and then divided them. Next with my hand I pushed the peritoneum and its contents upwards and inwards, and took hold of the external iliac artery with my finger and thumb. . . . It only now remained that I should pass a ligature round the artery and tie it." ("Surgical Works," vol. i., page 254.)

Abernethy later thought he had "disturbed the peritoneum too much and tied the artery higher than was necessary." He therefore modified the operation to the extent of making the incision lower down.

What was known as Abernethy's operation is described by South in 1847 ("Chelius's Surgery") in this manner. The incision was four inches in length, and was commenced one inch and a half above and to the inner side of the anterior superior iliac spine, and was carried down in the direction of the external iliac artery, to a point half an inch above Poupart's ligament. This incision is shown in Fig. 344. The muscles were divided in order, the peritoneum exposed and pushed back in the manner already described.

Comment, and Comparison of the Two Operations.—The comments made upon the previous operation apply, with obvious modifications, to the present method.

Abernethy's operation enables the artery to be ligatured higher up, and the incision is away from the centre of the groin. This is a matter of consequence in dealing with a case of aneurysm involving the upper part of the femoral artery, and possibly encroaching upon Poupart's ligament.

The wound, moreover, is removed from the abdominal rings, and does not concern the deep epigastric artery.

Cooper's operation, however, must be regarded as the better of the two, and it claims that position upon the following grounds : The operation is easier to perform. The peritoneum is dealt with at a spot where it is but little adherent. It is, in consequence, more readily displaced, and is less exposed to damage.

There is infinitely less division of the muscular structures of the abdominal parietes, the wound is simpler, and the disposition to ventral hernia is less.

The artery is exposed at a great depth in Abernethy's operation, and the wound is so placed that the passage of the aneurysm-needle is attended with great difficulty, and with unusual risk of wounding the vein. The exposure of the deep epigastric artery would appear to be no objection to the operation advised. It is easily avoided. It has not been shown that any special evils have attended the making of the incision close to the openings of the inguinal canal.

2. THE INTRAPERITONEAL METHOD

Accounts of this operation are given by Sir W. Mitchell Banks (*Brit. Med. Journ.*, Nov. 26th, 1892), and by Mr. Makins (*Lancet*, 1893, vol. ii., page 196). The patient is prepared as for an abdominal operation, and all the precautions adopted in such an operation are observed. The patient should be placed in the Trendelenburg position, which causes the intestines to fall away from the artery. The incision is made in the semilunar line close above the groin, and is about 3 inches in length. Any coils of bowel which may present themselves in the operation area are kept away either by sponges or by a suitable retractor, or by both. As soon as the artery is exposed, the posterior parietal peritoneum which covers the vessel is picked up and is neatly divided directly over the artery and parallel to the long axis of the vessel. Care is taken of the various structures which cross the artery, and which are enumerated in the account of the anatomy of the vessel (pages 418–19). The needle is passed from the vein.

Care must be taken to avoid the deep epigastric artery in dividing the parietes. This vessel will probably have to be

ligatured and divided. The incision in the posterior parietal peritoneum must be free, in order that the artery may be well exposed and the structures in relation with it precisely identified. A good light is needed. Some surgeons suture the divided posterior peritoneum over the artery, but such a measure is not called for.

Collateral Circulation after Ligature of the External Iliac Artery.

Above.		*Below.*
Internal mammary, lumbar and lower intercostal	with	Deep epigastric.
Lumbar and ilio-lumbar	with	Deep circumflex iliac.
Obturator and sciatic	with	Internal circumflex.
Sciatic	with	Superior perforating.
Gluteal	with	External and internal circumflex, and first perforating.
Internal pudic	with	External pudic.

For the varieties of the artery, *see* page 433.

The Common Iliac Artery

Anatomy.—The common iliac artery is about two inches in length, and has a diameter of 11 to 12 mm. The right vessel is a little longer and usually a little larger than the left. The aorta bifurcates opposite to the centre of the body of the fourth lumbar vertebra, and a little to the left of the middle line. This point corresponds to a spot about three-quarters of an inch below and just to the left of the umbilicus, and is on a level with a line drawn transversely between the highest parts of the two iliac crests.

The common iliac bifurcates opposite to the lumbo-sacral articulation.

The vessel is covered by peritoneum, and has running over it many sympathetic nerve fibres on their way to the hypogastric plexus. The ureter runs athwart the vessel near its bifurcation.

The left vessel lies close to the bodies of the fourth and fifth lumbar vertebræ, and alongside of the psoas muscle. The artery on the right side is separated from the psoas and the vertebræ by the two common iliac veins.

The relation of the veins to the arteries is shown in Fig. 343. It will be seen that the vena cava and both common

iliac veins are in close connection with the right common artery.

The vessels tend to become tortuous in old age.

The Line of the Artery has already been given (page 419).

Indications.—There are very few circumstances in which ligature of this vessel may be considered justifiable.

It has been secured in cases of wound of the artery, and in hæmorrhage from the external or internal iliac, or from the branches of the latter trunk.

It has been ligatured for the relief of aneurysm of the external or internal iliac, and as a preliminary to the removal of large vascular growths.

An interesting method of temporary closure (not ligature) of the common iliac artery may be urged as of practical value—we refer to clamping it in order to render amputation at the hip-joint as bloodless as possible.

The procedure is exactly the same as for ligature of the artery. The extraperitoneal route is the best way of approach. A metal clamp—after the style of Makins's intestinal clamp—is very suitable for the purpose. It is neither necessary nor advisable to cover the blades with rubber. At the London Hospital Mr. E. Hurry Fenwick and myself (J. H.) have both successfully carried out this method—the hæmostasis was certainly much better during the amputation than that secured by any other method we have tried. It will be seen that temporary occlusion of the common iliac artery shuts off the entire distribution of both internal and external iliac arteries, yet so free is the anastomosis that a certain amount of bleeding still occurs.

The vessel was first tied in 1812 by Professor W. Gibson, of Philadelphia (*Amer. Med. and Surg. Recorder*, vol. iii., page 185), for gunshot wound of the artery. The peritoneal cavity was opened up. The patient died on the thirteenth day.

Dr. Mott, of New York (*Amer. Journ. of Med. Sciences*, vol. i., page 156), carried out the first extraperitoneal operation in 1827, for aneurysm of the internal iliac artery. The patient did well. The mortality of the operation has been very high. Lidell reports only sixteen recoveries in sixty-eight recorded cases. The very great majority of these operations took place before the introduction of antiseptic surgery, and some of the

patients died of causes which happily are no longer unpreventable.

The intraperitoneal way of approach is more modern, and has some advantages, but the older method can also claim advantages.

I. THE EXTRAPERITONEAL OPERATION (ANTERIOR INCISION)

The preparation and position of the patient are the same as have been already described in dealing with the external iliac artery (page 421).

In stripping off the peritoneum the patient should be turned a little upon the sound side, in order that the intestines may be carried away from the wound area.

The incision on the right side may be made from above downwards, and on the left from below upwards.

A good light is required. Broad spatulæ or retractors are needed, and the surgeon should have provided himself with that form of aneurysm-needle which practice of the operation upon the dead body has shown to be the most convenient. A large, long needle with a lateral curve will probably be found the most convenient.

(1) **Mott's Operation.**—An incision from five to eight inches in length is commenced just outside the centre of Poupart's ligament and one inch and a half above it.

It then curves upwards and outwards in the direction of the ribs, passing the crest of the ilium one inch and a half in front (i.e. to the inner side) of the anterior superior spinous process. (*See* Fig. 344, *c*.)

The skin and subcutaneous tissues are divided, and the aponeurosis of the external oblique is exposed, together with—in the upper part of the incision—a portion of the muscle itself. Both aponeurosis and muscular fibres are divided in the line of the original incision. The internal oblique muscle is now reached, and is cut through in the same manner.

The transversalis muscle is in turn exposed, and its fibres are severed from one end of the wound to the other.

Between the two last-named muscles will be met the ilio-

hypogastric, ilio-inguinal, and last dorsal nerves, and probably the ascending branch of the deep circumflex iliac artery. If the incision be carried high up, other dorsal (intercostal) nerves are met with.

The transversalis fascia is well exposed, and is divided along the whole length of the wound.

The peritoneum is now very carefully stripped from the iliac fascia, and the external iliac artery sought for. The serous membrane is pushed aside in the manner already described (page 423), until the common iliac trunk is reached. The ureter is pushed aside (i.e. upwards and inwards) with the peritoneum.

The coat of the artery is well exposed, and the needle should be passed, on either side of the body, from right to left.

There is considerable risk of injuring the vein. The ligature should be applied, if possible, to the middle of the artery.

(2) **Marcellin Duval's Operation.**—The incision is about five inches in length. It is commenced one inch and a quarter to the outer side of the spine of the pubes, a little above Poupart's ligament. The first inch and a half of the incision is parallel with Poupart's ligament. The incision is now sharply curved upwards, and ultimately follows a line which is perpendicular to the ligament, and is directed towards a point one inch and a quarter to the outer side of the umbilicus. (*See* Fig. 344, *d.*)

The three abdominal muscles are divided, together with the transversalis fascia, and the artery is reached by pushing aside the peritoneum in the manner already described.

Comment.—The general observations made upon the operation for ligaturing the external iliac artery (page 424) apply equally to this procedure. There is great danger of wounding the peritoneum. A very efficient retraction of the soft parts is essential, and the passing of the needle is associated with considerable difficulty.

Mott himself made an incision five inches long, beginning immediately above the external abdominal ring, and continued in a semilunar direction half an inch above Poupart's ligament to a little above the anterior superior iliac spine. This incision was too low down.

The operation described is easy, so far as the exposure and separation of the peritoneum are concerned; but the vessel is reached at a great depth, and the passing of the needle is attended with considerable difficulty.

Duval's procedure would appear to be the best of the anterior extraperitoneal operations. The artery is well and easily exposed. The wound, however, in the abdominal muscles is of considerable extent, and the conditions favourable to ventral hernia are somewhat increased. The wound in the parietes should be closed by buried sutures.

2. THE EXTRAPERITONEAL OPERATION (LATERAL INCISION)

This operation was first carried out by Sir P. Crampton, and is described by him in the following words (*Med.-Chir. Trans.*, vol. xvi., page 161). The loin is well exposed, the patient lying upon the sound side. "The first incision commenced at the anterior extremity of the last false rib, proceeding directly downwards to the ilium. It then followed the line of the crista ilii, keeping a very little within its inner margin, until it terminated at the superior anterior spinous process of that bone. The incision was therefore chiefly curvilinear, the concavity looking towards the navel. The abdominal muscles were then divided to the extent of about an inch, close to the superior anterior spinous process, down to the peritoneum. Into this wound the forefinger of the left hand was introduced, and passed slowly and cautiously along the line of the crista ilii, separating the peritoneum from the fascia iliaca. A probe-pointed bistoury was now passed along the finger to its extremity; and by raising the heel of the knife, while its point rested firmly at the end of the finger, as on a fulcrum, the abdominal muscles were separated from their attachments to the crista ilii by a single stroke.

"By repeating this manœuvre the wound was prolonged until sufficient room was obtained to pass down the hand between the peritoneum and the fascia iliaca. Detaching the very slight connection which these parts have with each other, I was able to raise up the peritoneal sac with its contained intestines on the palm of my hand, from the psoas magnus and iliacus internus muscles, and thus obtain a distinct view of all the important parts beneath; and, assuredly, a more striking view has seldom been presented to the eye of the surgeon. The parts were unobscured by a single drop of blood: there lay the great iliac artery, nearly as large as my finger, beating awfully at the rate of two in a second, its yellowish white

coat contrasting strongly with the dark blue of the iliac vein, which lay beside it, and seemed nearly double its size. The ureter, in its course to the bladder, lay like a white tape across the artery, but in the process of separating the peritoneum it was raised from it with that membrane, to which it remained attached. . . . Nothing could be more easy than to pass a ligature round an artery so situated. The forefinger of the left hand was passed under the artery, which, with a little management, was easily separated from the vein ; and on the finger (which served as a guide) a common eyed-probe, furnished with a ligature of moistened catgut, was passed under the vessel."

Comment.—Compared with Mott's operation, this procedure has certain decided advantages. The actual operation is much easier ; the peritoneum is less disturbed, and is more readily separated ; the artery is brought actually into view, and the ligature is passed with comparative ease ; there is less probability of the formation of a ventral hernia ; and, lastly, the wound affords better conditions for efficient drainage. Between Crampton's operation and that of Marcellin Duval there is a less conspicuous comparison. In both, the artery is well and admirably exposed. In stout and muscular subjects the lateral wound may have to be carried to a great depth ; but, on the other hand, it is in a position in which the probabilities of a ventral hernia are decidedly less than in the anterior operation.

3. THE INTRAPERITONEAL OPERATION

The artery is best reached through the abdominal cavity, and now that the principles of aseptic surgery have rendered the opening of that cavity safe, there is no doubt but that the intraperitoneal operation will come more into use. The abdomen is opened by an incision in the median line, which will be placed between the symphysis and the umbilicus, and will probably have to be extended so as to reach both those points. The Trendelenburg position has the advantage of keeping the intestines out of the way. Such coils of bowel as present themselves are kept away from the operation area by sponges and retractors.

The peritoneum over the artery is divided by a vertical incision and the vessel well exposed. The needle is best passed

from the vein—i.e. from right to left in dealing with the left common iliac, and from left to right in dealing with the opposite artery. Mr. Makins observes (*Lancet*, 1892, vol. ii., page 1328): "Ligature of the *right* common iliac artery by the intraperitoneal method is probably the easiest of all the operations on the great arteries, since the vessel lies directly beneath the peritoneum of the posterior abdominal wall, uncovered by any structure of importance. On the *left* side, on the other hand, the inferior mesenteric vessels as they enter the sigmoid mesocolon and pass down to the mesorectum cover practically the whole of the artery, and to reach the common iliac comfortably and safely the peritoneum would need to be divided close to the left of the median line of the sacrum and be displaced outwards. This manœuvre has the disadvantage of exposing the vein freely, but this would probably give far less trouble than the numerous mesenteric vessels would when swollen by reason of the loss of their peritoneal support."

Collateral Circulation after Ligature of the Common Iliac Artery.

Above.		*Below.*
Internal mammary and lower intercostals	with	Deep epigastric.
Lumbar	with	Deep circumflex iliac and ilio-lumbar.
Superior hæmorrhoidal	with	Hæmorrhoidal branches of internal iliac,
Middle sacral	with	Lateral sacral.
Pudic, epigastric, obturator, and visceral arteries	with	The corresponding vessels on the opposite side.

Varieties of the Iliac Arteries.

1. The aorta may bifurcate a little below or, in rarer instances, a little above the normal situation.
2. The common iliac arteries may bifurcate above or below the point indicated, and may vary in length between one inch and a half and three inches.
3. The deep epigastric artery may arise from the external iliac one and a half or even two and a half inches above Poupart's ligament. The deep circumflex artery may arise as high as one inch above the ligament.

4. The internal iliac artery may vary in size from half an inch to three inches, and its place of division may be at any point between the upper margin of the sacrum and the upper border of the sacro-sciatic foramen.

The Internal Iliac Artery

Anatomy.—This vessel, which measures from one inch to one inch and a half in length, extends from the bifurcation of the common iliac to the upper margin of the great sacro-sciatic notch, where it breaks up into its ultimate branches.

It lies at first near the inner edge of the psoas muscle, and then upon the sacrum and lumbo-sacral cord. It is covered by the peritoneum, and is crossed by the ureter at its commencement. The vein lies behind and somewhat to the inner side (Fig. 343). The varieties of the artery have been detailed above.

Indications.—The circumstances under which this operation is justifiable are very few. It has been ligatured for hæmorrhage, but with very unsatisfactory results. Lidell states that out of twenty-seven recorded examples of the operation, only eight recoveries can be claimed. The great majority of the successful cases are instances of ligature for the cure of gluteal aneurysm. It has been employed also to delay the growth of inoperable sarcomata.

The operation was first performed with success by Dr. W. Stevens, of Santa Cruz, in 1812, for aneurysm (*Med.-Chir. Trans.*, vol. v., page 422). He made an incision five inches in length, through the anterior abdominal parietes, parallel with the deep epigastric artery and about half an inch to the outer side of it. The peritoneum was pushed aside, and the artery reached as in the operation for ligature of the common iliac.

1. THE EXTRAPERITONEAL OPERATION

The incision employed is the same as that made to secure the common iliac artery, the procedure of Marcellin Duval being the best suited for the purpose (page 430).

The preparation of the patient, the position assumed, and the general features and special dangers of the operations for

securing the iliac arteries, have already been dealt with in the sections on the common iliac and the external iliac.

In the present case the peritoneum is pushed aside until the external iliac is reached. The surgeon is guided to the internal artery by following the more superficial trunk. The upper margin of the great sacro-sciatic notch is easily identified, and will serve to indicate the lower end of the artery. The passing of the ligature is difficult, and many aneurysm-needles, of various sizes and with various curves, should be at hand. The needle should be passed, on either side of the body, from within out.

2. THE INTRAPERITONEAL OPERATION

This operation represents the best method of reaching the internal iliac artery, and will no doubt replace the older method just detailed. This procedure was advocated by Dr. Dennis, of New York (*New York Med. News*, November, 1886). He reported three cases, in all of which the ligature was applied for aneurysm. In one case the right internal iliac was secured, and in another the left. Both patients were cured. In the third instance both internal iliacs were ligatured. The patient, a woman of sixty, died on the third day. I (F. T.) ligatured the artery with success in a boy aged sixteen, for a vascular tumour of the buttock, in November, 1889, by this method.

The patient having been placed on the table in the Trendelenburg position, the abdomen is opened in the middle line by an incision extending from the symphysis pubis to the umbilicus, or to a point a little above it (Fig. 344, *f*). The intestines having been pushed up and drawn aside, the area of the deep wound is surrounded by sponges, and so cut off from the peritoneal cavity. I employed six sponges in this way, and had the wound well opened and the sponges kept in position by large metal retractors.

The peritoneum over the artery is thus well exposed, and is divided to the extent of one inch and a half. The artery is followed down from the bifurcation of the common iliac. The vein will appear to be about three times the size of the artery, and the separation of the two is a matter of some delicacy. The vein indeed presents the chief difficulty in the operation. Care should be taken that the ureter is not damaged nor

accidentally included in the ligature. The many sympathetic nerve fibres which follow the artery may be avoided if the coat of the vessel be well exposed.

A fair number of similar operations on cases of soft and rapidly growing tumour of the gluteal region might be collected, but the ultimate measure of success obtained is so small that the procedure is hardly worth attempting.

A good light, several broad retractors or spatulæ, long dissecting forceps, and a variety of aneurysm-needles are required. The operation should be performed with the care which is essential in every abdominal section. (*See* Ligature of the Common Iliac, page 427.)

Comment.—The advantages of this method are obvious. The vessel is easily and fully exposed, and the needle can be passed without risk to the vein or the ureter. The operation is simple, and involves but little time. Its dangers are, comparatively speaking, very few. The ligature can be applied accurately at the spot determined upon. The condition of the artery and of the surrounding parts can be made out, and a diagnosis confirmed or modified.

Collateral Circulation after Ligature of the Internal Iliac Artery.

Above.		*Below.*
Middle sacral	with	Lateral sacral.
Inferior mesenteric	with	Hæmorrhoidal arteries.
Branches of profunda femoris	with	Sciatic and gluteal.
Circumflex iliac	with	Ilio-lumbar.
Internal pudic and obturator	with	The vessels of the opposite side.

Branches of the Internal Iliac Artery

1. **The Gluteal Artery.** *Anatomy.*—This, the largest branch of the internal iliac artery, turns round the upper margin of the great sacro-sciatic foramen, and separates, opposite the interval between the gluteus medius and pyriformis, into two divisions, a superficial and a deep. The former passes backwards between the gluteus medius and pyriformis, and reaches the great gluteus.

The latter runs forwards between the gluteus medius and gluteus minimus.

The vein lies anteriorly to the trunk of the artery, and the superior gluteal nerve is placed a little below it.

Line of the Artery.—If a line be drawn from the posterior superior

iliac spine to the top of the great trochanter, when the thigh is rotated in, a point at the junction of the upper with the middle third of that line will correspond to the point at which the gluteal artery emerges from the sciatic notch (Fig. 347, A, B). Another landmark is the centre of a line drawn between the tip of the coccyx and the highest point of the iliac crest. The incision may be made at right angles to this line.

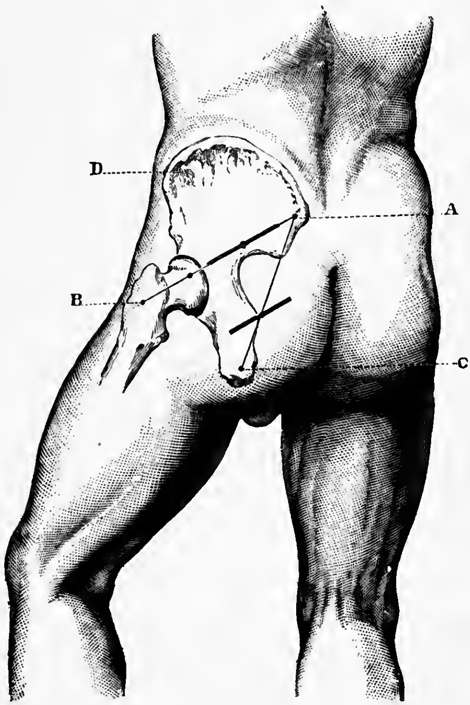

FIG. 347.—INCISIONS FOR THE GLUTEAL, SCIATIC, AND PUDIC ARTERIES.

A, Posterior superior iliac spine; B, Great trochanter; C, Tuber ischii; D, Anterior superior iliac spine; A-B, Gluteal line; A-C, Sciatic and pudic line (MacCormac).

Indications.—This operation can very rarely be called for. It has been performed with success in cases of stab wound, in a case of hæmorrhage following the evacuation of a gluteal abscess, and in certain examples of false aneurysm.

The artery was first ligatured by John Bell in 1808 for false aneurysm (" Principles of Surgery ").

Operation.—The patient is rolled nearly over on to the face; the limb is allowed to hang over the edge of the table; the thigh is rotated in. The surgeon stands upon the side to be dealt with.

An incision five inches in length is made along the line just given. The centre of the incision should correspond to the point of exit of the artery (Fig. 347).

After dividing the skin and superficial fascia, with a few cutaneous nerves, the gluteus maximus is reached, covered by its fascia. The incision runs parallel with the fibres of the muscle. These fibres are separated in the line of the wound until the thickness of the muscle has been traversed. A muscular branch—from the superficial division of the artery—may here be met with, and will form a guide to the trunk.

The deep fascia between the glutei muscles is reached, and the contiguous margins of the gluteus medius and pyriformis muscles are exposed.

The gluteus maximus is now relaxed by placing the fully extended thigh upon the table. The interval between the gluteus medius and pyriformis is opened up with retractors, and the upper margin of the sciatic notch defined. The superficial division of the artery passes between the two muscles, and leads the operator's finger to the main trunk. The ligature should be applied as far within the notch as possible—almost within the pelvis—inasmuch as the artery breaks up into its two divisions as soon as it has cleared the notch.

Care must be taken to include neither the nerve nor the vein.

It is very easy to wound the vein with the point of the director, etc., and this accident should be carefully avoided.

In order to obtain a fuller view of the vessel, some fibres of the great sacro-sciatic ligament may require to be divided.

2. **The Sciatic and Internal Pudic Arteries.**—The ligature of these vessels has scarcely ever been called for in actual practice. The operation has been performed for some uncommon examples of wound.

Anatomy.—The sciatic and pudic arteries descend together in front of the pyriformis muscle, and leave the pelvis by the lower part of the great sacro-sciatic foramen. The sciatic continues its course downwards under cover of the gluteus maximus, and rests upon the obturator internus and gemelli muscles.

The pudic curves forward over the ischial spine, and enters the pelvis again by the small sacro-sciatic foramen.

At the lower margin of the pyriformis muscle the sciatic artery is superficial to the pudic, and passes behind it to gain its outer side. Both vessels are accompanied by venæ comites. To the inner side of the pudic artery, at the lower border of the pyriformis, lie the internal pudic nerve and its inferior hæmorrhoidal branch.

The sciatic artery, near the same place, is superficial (i.e. posterior) to both the small and the great sciatic nerves.

Operation.—The point at which the sciatic and pudic arteries emerge from the pelvis and reach the gluteal region is indicated by a line drawn (when the thigh is rotated in) from the posterior superior iliac spine to the outer part of the tuber ischii (Fig. 347, A—C). The point in question is at the junction of the middle with the lower third of this line.

An incision, some four inches in length, is made obliquely across this line in the direction of the fibres of the gluteus maximus, and

is so placed that its centre corresponds to the point just indicated (Fig. 347).

The gluteus maximus is divided in the line of the wound, and the lower margin of the pyriformis muscle and the spine of the ischium are well defined.

The ligature should be passed as near to the pelvis as possible.

The Abdominal Aorta

So far as the present history of this operation is concerned, the ligation of the abdominal aorta cannot be considered to be a justifiable procedure.

It has been resorted to in severe cases of iliac and inguinal aneurysm which have resisted all other modes of treatment, and has been practised for the arrest of both primary and secondary hæmorrhage.

The aorta was first ligatured by Sir Astley Cooper in 1817 (" Prin. and Prac. of Surgery," vol. i., page 228), by opening up the abdominal cavity in the median line. In all, some fifteen cases of this operation have been collected, but as the result has been invariably fatal we see no object in giving further details.

CHAPTER VI

OPERATIONS ON VEINS

The operations specially performed upon veins are practically of only two kinds, namely the excision between ligatures of varix of the leg, and the ligature (sometimes with drainage) of the internal jugular vein of the neck in cases of lateral sinus infection.

I. EXCISION OF VARICOSE VEINS OF THE LOWER LIMB

Careful selection of cases suitable for this operation should be made in order to avoid disappointment. The most favourable ones are those in which one group or system of superficial veins have become dilated—for example the internal or external saphenous trunk and their branches. Where a great number of small varicosities are present, whilst no main vein is enlarged, more relief will be given by an elastic stocking or bandage than from an operation. Again, extreme varicosity may be due to some temporary cause, such as pregnancy, and here no operation should be resorted to.

When a varicose condition of a limb is complicated by severe eczema or ulceration of the skin, operation is attended with special risk, and should not be performed, as a rule, until this complication has been got rid of. In many cases the operation is performed in order to qualify the patient to enter one of the services.

The patient should always be examined when standing up, and a careful note made as to whether the enlarged veins are confined to the leg, or whether the dilatation extends into the thigh (the internal saphenous-trunk). The operation, to be effective, must be thorough, and for this reason we do not recommend the so-called Trendelenburg's operation, which consists merely in exposing and tying the internal saphenous at its highest point in Scarpa's triangle. Experience has shown that this procedure, whilst it may now and then give some relief,

may actually increase the dilatation below and on the whole gives very poor results. Its sole recommendation is the rapidity with which it can be performed.

When the patient is examined in the erect position it is a good plan to mark the skin over all the chief dilated veins with an aniline pencil after the usual disinfection of the skin has been performed. Otherwise the operator will have difficulty in finding the veins, so little do they show up after the patient has been recumbent.

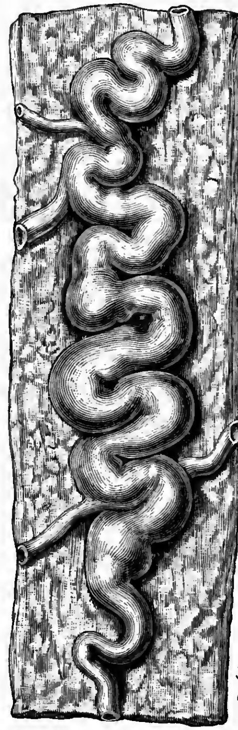

FIG. 348.—LIMITED VARICOSITY OF VEIN OF LEG—VERY SUITABLE FOR OPERATION.

The lateral branches would have to be ligatured as well as the two ends of the main vein.

The Operation.—The skin incision over the veins should be planned so as to expose the maximum length of the affected vessels whilst not risking the vitality of the skin itself. As a rule the best form for the incision is a somewhat sinuous one, like an elongated letter S, as shown in Fig. 349. This incision allows of considerable lateral retraction and exposure of branches or tributaries of the vein over which it is placed. At the same time there is no more risk of sloughing or imperfect healing of the wound than from a linear incision. Anything approaching a transverse cut should be avoided, for there is no part of the body in which the skin heals with more difficulty than the leg in a patient who has been long subject to varicose veins.

The incision is carried down to the purple wall of the vein along its whole length, but where it is necessary to remove a varix involving both leg and thigh, the incision should be interrupted opposite the knee-joint. In fact, two or more incisions, each about three to five inches long, will as a rule give sufficient access, and a better ultimate result than a single very long one.

The somewhat tedious dissection of the vein and its branches

will be much helped by the use of a very sharp scalpel, and by the following detail. The vein being well exposed throughout the incision, one end of it is isolated and tied with catgut of medium thickness. It is then held with Wells' forceps and divided between this and the ligature. The divided end being then drawn upon, a few touches of scalpel or blunt dissector will detach the vein from its bed of connective tissue for a long distance, any branches being ligatured or caught with forceps before division. All chance of injury to the cutaneous nerves which run close to the veins is thus avoided. Finally, catgut ligatures are applied to the other end of the vein, and to any clamped branches, the wound being lightly washed with sterile water and sewn up. We have tried many ways of suturing these wounds, and recommend fine silkworm gut for the purpose—used in interrupted sutures which are left in for at least ten days. If a continuous catgut suture is employed, the edges almost always gape when this comes away at the end of a few days. It is, however, safe to employ the continuous catgut suture if reinforced at short intervals by interrupted sutures of silkworm gut.

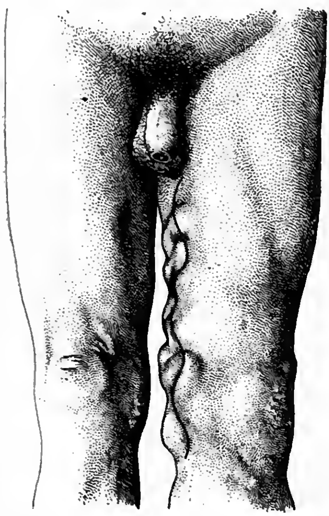

FIG. 349.—INTERNAL SAPHENOUS VEIN, VARICOSE FROM THE KNEE UPWARDS. THE CURVED INCISION FOR ITS EXPOSURE IS SHOWN.

The patient should rest in bed longer than is required for many operations of equal gravity, for, as we have endeavoured to impress upon the reader, perfect healing of these wounds is slow, owing in part to the poor arterial supply of the skin. He should, therefore, not get up for three weeks after the operation. If a splint has been used for the first few days, it should be soon dispensed with, and some play may be allowed to both knee- and ankle-joints. A light elastic webbing bandage should, as a rule, be worn for some months after the patient gets about, though it may ultimately be dispensed with.

Excision of Recently Thrombosed Varicose Veins.—Sometimes—but not often—this operation is justifiable, because it will lessen the period of confinement to bed. The more limited and superficial the thrombosis, the more favourable is the case for operation. The surgeon will be surprised, however, to find how far up the vein the coagulation has extended. The dissection out of the typical cake-like mass—consisting of convolutions of plugged vein with infiltrated and stained connective tissue—is no easy matter. Perfect healing of the wound is even more difficult to obtain in these circumstances than when the vein to be excised is simply dilated and not plugged.

2. LIGATURE OF THE INTERNAL JUGULAR VEIN, WITH OPERATION ON THE LATERAL SINUS

The landmarks for the lateral sinus and the question of opening it in certain cases of purulent middle-ear disease have been already referred to (p. 67).

Infection usually starts in the sigmoid curve of the lateral sinus by extension backwards from the mastoid antrum or cells. Hence the first step should be free opening and disinfection of the antrum, followed by removal of the bony wall over the sinus. This is effected by a burr, or by chisel and mallet, preferably the former. It will be remembered that the lateral sinus deeply grooves the posterior half of the mastoid process, and a line from the depression (easily felt) at the posterior inferior angle of the parietal bone to the tip of the mastoid process will lie directly over the sinus. The wall of the latter should be carefully exposed and followed down with bone-cutting forceps or burr for at least half an inch. If the sinus wall shows signs of inflammation, if it is discoloured or thickened, the surgeon should not hesitate to incise it. If a fine syringe-needle, passed through the wall into the cavity of the sinus, draws off blood that is unhealthy or half-coagulated, or if no blood can be withdrawn owing to coagulation, the sinus must be opened. But if neither of these tests reveals evidence of disease, it is probable that the diagnosis has been mistaken, and the sinus should be left alone. If necessary it can be punctured or opened later, should the symptoms recur. It may be noted that of these symptoms headache, optic neuritis, giddiness with rigors, and severe

pain about the mastoid process are the most important, and that sometimes tenderness or hardness over the internal jugular vein below the skull is noticed.

Supposing that sinus thrombosis is present and the venous cavity has been opened, the clot should be cleared out with a sharp spoon or fine forceps. If no blood wells up from the lower end on pressure over the jugular vein, the operator may infer that there is a firm plug, and he may desist from further intervention (Schlatter). But many surgeons prefer to tie the jugular vein in the neck, so as to prevent septic emboli being carried downwards. It should be mentioned that simple ligature of this vein has sometimes been successful without opening the sinus.

Little need be said about the operative details of ligature of the internal jugular vein. It is exposed at the level of the hyoid bone by the same incision as for ligature of the carotid artery (page 379). The director is used with all possible care in isolating the vein, and the vagus nerve is avoided in passing the aneurysm-needle and ligature. "Dividing the vein between two ligatures is preferable to a single one, as it permits of a more exact inspection of the interior of the vessel, and also evacuation of the peripheral portion of the jugular vein, if this should prove necessary" (Schlatter, von Bergmann's "Surgery," i. 304).

To recapitulate: in cases of suppurative otitis, where the supervention of rigors, headache, local tenderness, etc., make the diagnosis of infection of the lateral sinus probable, no time should be lost in performing a mastoid operation with exposure of the sigmoid sinus. If the wall of the sinus is found to be healthy it should not be opened, but if diseased the jugular vein below should be ligatured, the sinus opened, and as far as practicable the clot washed out or removed in other ways. Precautionary ligature of the jugular vein is practically free from risk, and surgical intervention on the lines laid down has been most successful in dealing with an otherwise fatal complication of suppurative otitis. Since Zanfal first urged the advisability of the operation in 1880 (his first case was done in 1884) very favourable statistics have been recorded. Thus Hessler collected 88 cases with 52 recoveries, and Sir W. Macewen lost only 8 out of 28 patients operated on for sinus complication.

CHAPTER VII

OPERATIONS ON NERVES*

NERVE-STRETCHING AND NERVE-SUTURE

THE chief subject to be referred to here is the suture of divided nerves, or Neurorraphy. Nerve-stretching must also be described, as it is still performed in certain cases of sciatica with good results. As regards other nerves than the sciatic, and in the treatment of other diseases (such as tabes and leprosy), nerve-stretching has almost entirely fallen into abeyance. Its effects are so uncertain, and any improvement is so fleeting, that this neglect is quite warranted. Neurotomy, or simple section of a nerve, has also proved to be useless in the treatment of neuralgia, though recently a proceeding has come into fashion—the injection of strong alcohol into the nerve-trunk involved—which is very much the same thing as section. Its effect, a spreading sclerosis, is perhaps more permanent in many cases than that of simple division of the nerve. Hence it should never be used where the latter is an important mixed nerve—i.e. conveying both motor and sensory impulses—as the permanent paralysis will be a very serious thing for the patient. For example, no surgeon would dream of cutting across the sciatic nerve in order to improve a case of sciatica, as he would thereby convert a painful into an incurably helpless lower limb. But, especially in Germany, the injection of alcohol into the sciatic nerve, or nerves nearly as important, has been done with similar deplorable results. Of course, a purely sensory nerve may be cut across or injected with alcohol with comparative impunity, though the resulting anæsthesia may be a considerable drawback.

* This chapter deals with operations upon nerves in all parts of the body except the head and neck. It seemed best to treat operations upon the fifth and other cranial nerves, and upon the cervical plexuses, in the section on the Head and Neck. The reader is therefore referred to pages 74-102 in this volume.

It may be laid down as a rule that simple section of any peripheral sensory nerve is always followed, after a few weeks or months, by return of sensation. Division of central nerve roots, e.g. those of the Gasserian ganglion or the posterior roots of the spinal nerves, is very rarely followed, however long a time may elapse, by complete return of sensation in the area of skin supplied.

The results of neurectomy, that is the extensive resection of nerves, are somewhat more permanent than those of neurotomy, etc. Hence longer relief is afforded by it in the treatment of neuralgia. A clear distinction must, however, be drawn between neurectomy of peripheral nerves and that of such peculiar central portions of the nervous system as the Gasserian ganglion. In the latter case removal or neurectomy of the ganglion usually effects a complete and lasting cure of the neuralgia, whilst neurectomy of any of the branches of the fifth, however close to the ganglion, will, after a certain number of months or years, be followed by recurrence.

It is impossible to prevent slight overlapping in the discussion of operations upon nerves. Many of them are almost confined to the region of the head and neck, and have, therefore, been discussed in that section. But nerve-stretching finds its chief use in the lower limb in the treatment of sciatica, while nerve-suture has its chief field in cases of wound of the forearm and arm.

1. **Nerve-stretching.**—This procedure has been applied to nerves of all kinds, both large and small ; to motor and sensory nerves, as well as to those of mixed composition. During the period in which a rage for nerve-stretching existed, even the optic nerve was stretched in cases of loss of vision (Wecker, 1881 ; Panas, 1882).

The measure has been employed in the treatment of various forms of muscular spasm (e.g. wry-neck, *tic convulsif*, tetanus), in peripheral neuralgias, in peripheral neuritis, in sciatica, in reflex epilepsy, in cases of hyperæsthesia, painful ulcer and painful stump, and for the relief of anæsthesia in leprosy, and lightning pains in locomotor ataxy. The results have, on the whole, not been satisfactory. Although isolated cases of im-

provement, mostly temporary, have been reported, nerve-stretching might well be abandoned except in the case of sciatica. Here it should be undertaken only after the thorough use of local and general remedies has failed, and with the knowledge that the result is quite uncertain.

The extensibility of nerves varies greatly, and is influenced by the size and situation of the trunk, its condition, the age and general state of the patient. It is said that a weight of about 6 lb. 10 oz. is required to extend the median nerve of an adult man three-fourths of an inch, and that the elasticity of the nerve is such that it will return to its normal length when the extending force is removed, even though the tension has been maintained for a few hours. Nerve trunks are more extensile near the spinal cord than at a distance, and in the upper than in the lower limb. This depends probably upon the strength of the nerve sheath, which is subject to variation, and against which the main strain of the stretching is directed.

Modus Operandi.—The nerve is exposed at its most convenient and usually at its most superficial part, and is then clearly isolated and brought well into view.

In the limbs the joints may be so flexed as to relax the parts about the site of the operation. Good retractors will usually be required. The larger nerve trunks are stretched by means of the finger and thumb, and smaller nerves by means of a suitable blunt hook.

"The nerve," writes Sir Victor Horsley, "being firmly held between the finger and thumb, is then to be steadily pulled for about five minutes, first centrifugally, and then centripetally for a like period of time. The tension must be gradually applied and kept constant the whole time, while all jerks (the force of which is unknown) are to be avoided. The actual amount of force with which it is advisable to pull varies from a maximum of thirty pounds for the sciatic nerve to half a pound for the supratrochlear. The amount of force must necessarily vary with individual development and the state of the nerve (Marshall). It will now be found that the nerve is loose and elongated, owing to its elasticity being relatively very imperfect." With regard to the sciatic nerve Marshall writes: "If I first pull as hard as I imagine I should do upon a living sciatic nerve during an operation, I find that the force employed is about equal to twenty pounds; but if I pull very hard, it is increased to thirty

pounds; and that, I believe, is as hard as a surgeon could well pull when holding a soft nerve between his finger and thumb."

The nerve having been replaced, the incision is closed.

The part should be kept absolutely at rest until the wound has entirely healed. Active and passive movements of the limb should then be gradually carried out, and some form of simple massage be employed.

The operation of stretching the great sciatic nerve is described in detail at page 455.

2. **Neurorraphy.**—This operation concerns the union of nerve trunks which have been severed by accident.

The term "immediate suture" is applied to cases in which the divided ends of the nerve are united within a short time of the accident; the term "secondary suture" to instances in which a period of time varying from weeks to months has elapsed between the receipt of the injury and the operation. It is needless to say that the former measure is the simpler and by far the more successful.

In the *immediate suture* the wound is perfectly cleaned, the cut ends of the nerve are brought together and united by sutures. Any bruised or jagged part of the exposed nerve is cut away. The general features of the operation are identical with those now to be described.

In the *secondary suture* the steps of the procedure are as follows:—

(1) The nerve is exposed. The incision is made over the course of the nerve and parallel to it. This part of the operation may be complicated by the presence of much cicatricial tissue and many adhesions, by wasting of adjacent muscles, by deformity, by the existence of a mass of callus about a fracture, and by much retraction of the nerve itself.

Even in a case of simple division of the nerve by a stab, an interval of from a half to one inch may be found to separate the divided ends. In instances where there has been much destruction the interval may be greater. The upper end of the nerve is more easily found than the lower. It is usually enlarged and bulbous.

The lower end, on the other hand, is usually atrophied and filiform, and is apt to be lost in cicatricial tissue.

It may be necessary to expose the trunk of the nerve lower down, and then to follow the cord upwards, in order to find the "lower end" with greater certainty. In any case the operator must be prepared to make a very free wound.

Whether the operation is an early or a deferred one, assistance in finding the ends will usually be obtained by bandaging either part of the limb, above or below the wound, towards the latter. Probably the whole limb will have already been made bloodless by an Esmarch's tourniquet.

Each portion of the exposed nerve should be freed for some distance respectively upwards and downwards, and the ends carefully drawn up in order to bring as much of the nerve as possible into the wound area to overcome the gap resulting from retraction, and to allow the extremities to be brought readily into contact.

(2) The two exposed ends are excised. This is best done with sharp small scissors. The cut must be clean and quite transverse. The bulb may be cut away layer by layer until a section of healthy nerve fibres is exposed. It is not always necessary to remove the whole of the bulbous end. Indeed, the firmer tissues of the bulb afford an excellent hold for the sutures. Bowlby advises that the section should pass through the upper end of the bulb, close to the trunk of the nerve.

With regard to the lower end of the nerve, Bowlby advises that it is only necessary "to cut away the extreme end, which, being matted with fibrous tissue and compressed by the surrounding scar, is very likely to contain no nerve tubules. It is seldom necessary to remove as much as a quarter of an inch, and, however unhealthy the section may look, no good is ever to be gained by a further sacrifice."

(3) The two ends are united by sutures. From two to six or eight sutures will be required, according to the size of the divided nerve. The material should be either fine silk or kangaroo tendon. The thread is passed by means of a curved needle. A small "intestinal" needle answers admirably. The needle should be introduced about a quarter of an inch from the free end of the nerve, and the thread should be carried through the whole

thickness of the trunk. If the sheath be substantial, or use can be made of the cicatricial tissue around the nerve, the sutures may be introduced into the extraneural structures. Sutures, however, which are limited to the sheath are of very little use. No harm has been shown to follow the passing of the needle through the substance of the nerve. If six sutures are to be applied, three may involve the nervous cord and three the sheath, or the connective tissue dissected up with it. The ends must be brought into close contact and be very accurately adjusted.

All rough handling of the nerve must be avoided.

In order to prevent fibrous tissue interfering with the point of nerve union, various plans have been tried, after the manner in which an electric wire is cased with a non-conducting sheath. A small cylinder of decalcified bone may be split and laid around the joined ends of the nerve, or Cargile's membrane may be rolled around them. Cargile's membrane is an animal product somewhat like guttapercha tissue, and is sold in small packets ready sterilised. It should be moistened in water before use. It is a very convenient material to use, and is more slowly absorbed than the decalcified bone cylinder. If Cargile's membrane is not at hand there can be no objection to the use of protective or guttapercha tissue, sterilised and rolled round the nerve like a cigarette-paper.

(4) The wound is closed. No drainage-tube is required, and every care should be taken to ensure the healing of the wound by first intention. The limb should be so adjusted that the parts concerned in the operation wound are relaxed and no traction is brought to bear upon the sutured nerve. For example, if the nerve concerned be the median in the forearm, both the elbow- and the wrist-joints should be flexed. The parts must be rigidly maintained in the desired position by means of splints, and should be well protected and kept warm.

As soon as the wound has soundly healed, passive movements, together with massage and galvanism, may be cautiously employed.

It sometimes happens that it is impossible to bring together the two ends without much tension. Under such conditions one of the following courses should be adopted.

(*a*) A segment half the thickness of the nerve may be carefully

detached for one, two, or more inches from the upper end and turned down, still retaining its connection with the extremity of the nerve. The upper end of this segment is then sectional to the pared lower end of the nerve. If this is not sufficient to fill the gap a segment from the lower end may be turned up to meet it.

(*b*) A piece of nerve from a lower animal, e.g. the popliteal of a dog or a rabbit, may be grafted between the two separated ends and carefully sutured. Even the spinal cord of an animal has been used for the purpose.

It must be pointed out that in neither case does the interposed portion directly restore continuity in a functional sense; all it does is to serve as a trelliswork or path along which new fibres may grow from the proximal end of the divided nerve.

The result of neurorraphy must depend upon many circumstances—upon the nature of the injury, the lapse of time since the nerve was divided, the amount of separation of the two ends, the local condition, the state of the patient's health, the amount of degeneration which has taken place, and the readiness with which the operation wound has healed. In any case it must be remembered that a very considerable time must be allowed to elapse before a surgeon can form an opinion as to the final results of the operation. Complete restoration of function will often require one or two years, and no improvement of any kind may be evident for several months after the neurorraphy. On the other hand, recovery of sensation is often noted within four to five weeks after successful primary suture

Much debate has arisen on the supposed immediate return of function in a nerve that has been completely divided and sutured shortly afterwards. The valuable researches of Dr. H. Head and Mr. Sherren have largely explained the cases where this incredible result was reported. In the first place it should be remembered that the areas of distribution of cutaneous nerves almost always overlap to some extent, and that some muscles receive a double nerve supply. Further, Dr. Head has proved that the various forms of sensation in the skin are not all transmitted by the obvious nerve channels that are said to supply any given area. Thus the sense of rough or deep pressure on the skin may pass by a different route from

that of the tactile sense or that which appreciates heat and cold. In the former case the message is probably transmitted by fine nerve twigs which accompany the arteries. It is of great interest that Dr. H. M. Johnston has proved by actual dissection of the intercostal nerves that fine branches are given off to the intercostal arteries, and run along them to the pleura, and to the skin of the abdominal wall. The researches outlined above have fully explained the mystery of the supposed examples of immediate return of function in a divided and sutured nerve.

The following notes refer to the operations which may be performed on the chief nerves of the limbs. Those of the head and neck have already been described (pages 74–102).

THE MEDIAN NERVE (PLATE XXIII.)

Anatomy.—This nerve is superficially placed in the arm and at the wrist, but has a deep course in the forearm. In the arm it is in close relation with the brachial artery, lying to its outer side above, crossing it about the middle of its course, and lying to its inner side at the bend of the elbow. In the forearm the median lies in the middle of the limb, between the deep and superficial flexors of the fingers. At the wrist it can easily be made out between the tendons of the flexor carpi radialis and the palmaris longus.

Operations.—1. In the arm the nerve can be exposed through such an incision as is employed to secure the brachial artery, e.g. in the middle of the arm (page 355).

2. At the wrist it is readily exposed through an incision about one inch and a half in length, which is parallel with the tendon of the flexor carpi radialis and close to its ulnar side. A superficial vein or so may be cut, the fascia is divided, and the nerve can at once be brought into view.

THE ULNAR NERVE

Anatomy.—The ulnar nerve is superficial in the arm, being covered only by the skin and fascia. It follows at first the line of the brachial artery, lying to the inner side of that vessel. It is then represented by a line drawn from the inner side of the artery about the level of the insertion of the coraco-brachialis

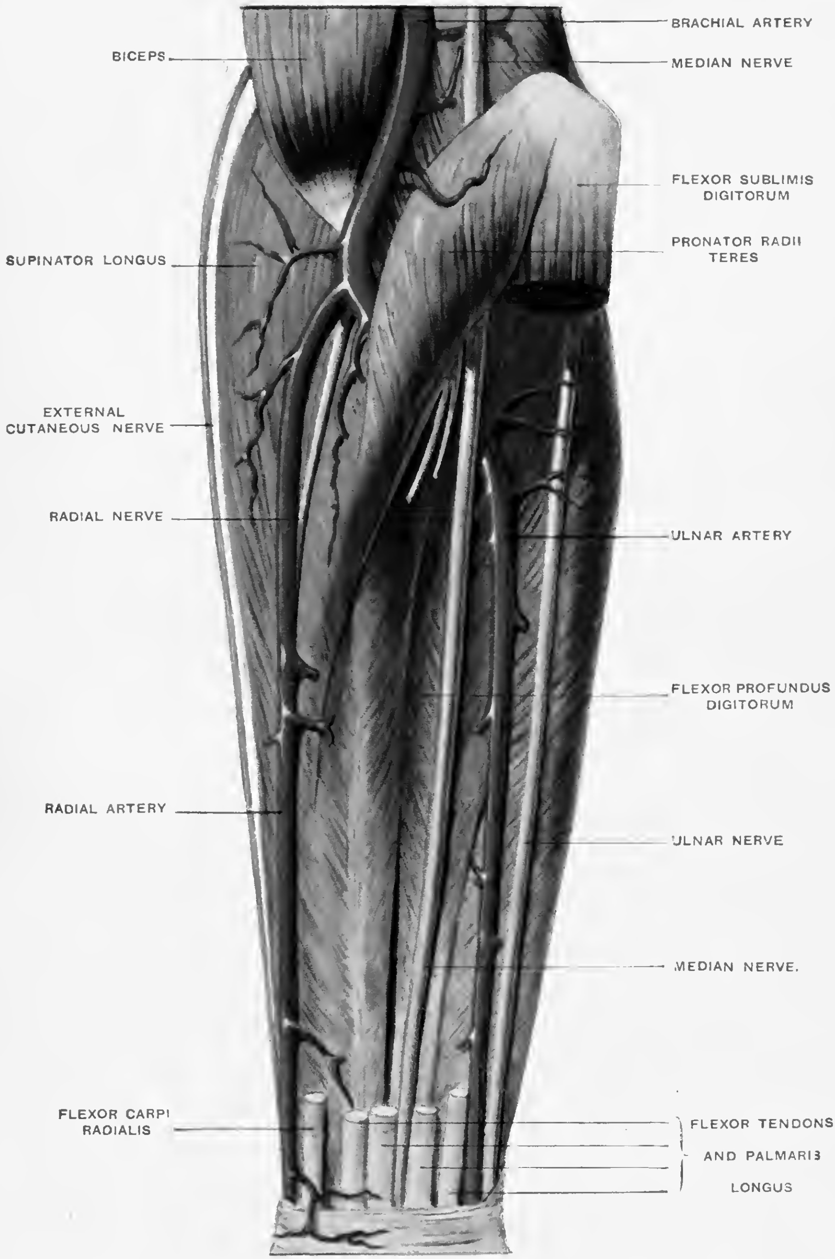

PLATE XXIII.—NERVES AND ARTERIES OF THE FRONT OF THE FOREARM.
(From a Dissection in the London Hospital Museum.)

to the gap between the inner condyle and the olecranon. In this latter part of its course in the arm it is accompanied by the inferior profunda artery, which lies to its outer side. It passes between the two heads of the flexor carpi ulnaris, and under cover of that muscle runs a straight course to the wrist.

In the upper two-thirds of the forearm it is deeply placed, but in the lower third it is superficial, having the tendon of the flexor carpi ulnaris on its inner side and the ulnar artery on its outer side. It crosses the anterior annular ligament between the pisiform bone and the ulnar artery. (*See* Plate XXIII.)

The dorsal branch to the hand leaves the trunk some two or three inches above the wrist.

At the elbow the nerve has very rarely been found passing in front of the internal condyle.

Operations.—1. Above the centre of the arm the nerve may be exposed by an incision parallel to the line of the brachial artery and half an inch to the inner side of it. In exposing the nerve care must be taken to avoid injury to the venæ comites of the brachial artery, the nerve of Wrisberg, and the ulnar collateral nerve, all of which are in near association with the trunk sought for.

2. The ulnar nerve is very conveniently exposed just above the internal condyle. The incision should be about one inch and three-quarters in length, and should lie upon the line for the nerve already given. The cut should extend to within about half an inch of the internal condyle. The nerve is found to lie along the back of the internal intermuscular septum with the inferior profunda artery, which is placed to its outer side.

3. Just above the wrist the nerve may be exposed by means of an incision one inch and a half long, made parallel to the tendon of the flexor carpi ulnaris and just to its outer side. After the integuments and fascia have been divided the nerve is brought at once into view, the artery lying to its radial side.

THE MUSCULO-SPIRAL NERVE

Anatomy.—Commencing behind the axillary vessels, this nerve runs backwards into the musculo-spiral groove, accompanied by the superior profunda artery; on reaching the outer side of the limb it pierces the external intermuscular septum,

about midway between the insertion of the deltoid and the tip of the external condyle, and, descending between the supinator longus and the brachialis anticus, divides about the level of the outer condyle into the radial and posterior interosseous nerves. The superior profunda artery, on reaching the outer side of the humerus, breaks up into two branches, the larger of which descends along the back of the intermuscular septum to reach the outer condyle, while the smaller follows the nerve into the groove between the supinator longus and brachialis muscles.

The nerve about the point at which it pierces the intermuscular septum will have given off the nerve to the long head of the triceps, the posterior internal cutaneous, the branches to the inner and outer heads of the triceps and to the anconeus, and the posterior external cutaneous.

In the groove between the supinator longus and the brachialis anticus it gives off branches to both those muscles, to the extensor carpi radialis longior and to the elbow-joint.

Operation.—The nerve is most conveniently exposed at the point at which it gains the outer side of the arm. The elbow is flexed and the arm carried a little across the patient's thorax.

An incision, from two to two and a half inches in length, is made obliquely across the outer surface of the arm at its lower third. The centre of the incision is made to correspond to a point midway between the insertion of the deltoid and the external condyle, and its obliquity is so determined that the lower part of the incision will follow the line of the upper border of the supinator longus.

The skin and fascia having been divided, the surgeon with his forefinger seeks for the nerve as it lies close to the bone, piercing the intermuscular septum and about to cross the upper limit of the supinator muscle. If the fibres of this muscle be exposed, the position of the nerve can be more readily determined.

The supinator muscle may be drawn outwards so as to demonstrate the groove between it and the brachialis anticus. The nerve may be carefully separated from the companion artery and drawn forward by means of a blunt hook.

THE GREAT SCIATIC NERVE (PLATE XXIV.)

Anatomy.—This, the largest nerve in the body, extends from the lower border of the pyriformis muscle to a point a little below the middle of the thigh, where it separates into its two divisions, internal and external popliteal. It rests upon the external rotators of the hip and upon the adductor magnus. It is covered behind by the gluteus maximus and the hamstring muscles. (*See* Fig. 350.) It lies in the hollow between the great trochanter and the tuber ischii, being a little nearer to the latter than to the former process of bone. The small sciatic nerve lies in the same line as the great cord, but superficially to it. The comes nervi ischiadici accompanies the great sciatic. The bifurcation of the nerve may take place at any point between the sacral plexus and the lower third of the thigh.

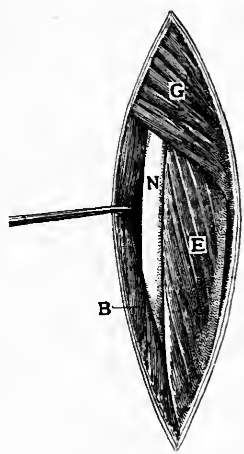

FIG. 350.—RELATIONS OF THE SCIATIC NERVE.
G., Gluteus maximus; N., Great Sciatic; B., Biceps; E., Adductor magnus.

The "fold of the buttock" is considerably above the level of the lower border of the gluteus maximus, with which therefore it does not correspond. When the hip is fully extended, as in the erect posture, the buttocks are round and prominent, the gluteal fold is transverse and very distinct. When the hip is a little flexed the buttocks become flattened, the gluteal fold becomes oblique and almost disappears.

Operation.—The nerve is most accessible for stretching if exposed at the lower border of the gluteus maximus muscle, just as it is leaving the hollow between the tuber ischii and the great trochanter. This corresponds to its most superficial part.

The patient should be turned sufficiently over upon the face to enable the buttock to be exposed and the thigh to be extended. A vertical incision, four inches in length, is then made in the course of the nerve. The incision should commence over the gluteal fold, and should be exactly opposite to the middle of the interval between the tuber ischii and the great trochanter.

If the wound be made nearer to the tuber there is an increased difficulty in displacing the hamstring muscles. The centre of the incision will about correspond to the free lower margin of the gluteus maximus. The skin and fascia having been divided, the small sciatic nerve and a few cutaneous arteries will be encountered. The quantity of the subcutaneous fat may be considerable.

The lower border of the gluteus maximus should be clearly exposed as it runs obliquely downwards and outwards. The edge of this muscle must be drawn upwards by means of a strong and broad retractor. The finger introduced into the wound will now encounter the hamstring muscles a little below their origin from the tuber ischii. These muscles should all be drawn inwards, their fibres having been first relaxed by bending the knee. They are retained in position by another strong and broad retractor.

The nerve should now be readily discovered and brought into view. It should be followed in both directions as far as possible, and a careful examination should be made for abnormal fibrous adhesions connecting the nerve trunk to the surrounding muscles, etc. If found they should be dissected away, and in every case the nerve should be freed by sweeping the index finger along it for a considerable distance, from the sciatic notch downwards. Dr. Crawford Renton, of Glasgow, has drawn special attention to the occurrence of perineural adhesions in cases of sciatica, and has removed them in a large proportion of his many operations for this complaint, with very good result. (J. C. Renton, "Contrib. to Clin. Surgery," 1905, p. 88, and elsewhere.) It appears that in the damp, cold climate of Scotland sciatica is especially prevalent, and rebellious to other than surgical treatment. We have searched for abnormal adhesions in the cases operated on by us without making sure of their presence, which is a difficult thing to decide. In every case, of course, whether "adhesions" are found or not, the nerve is stretched with the finger in the manner already described (page 447).

THE INTERNAL POPLITEAL NERVE

This nerve, the larger of the two divisions of the great sciatic, continues the direction of the main trunk, passes through the middle

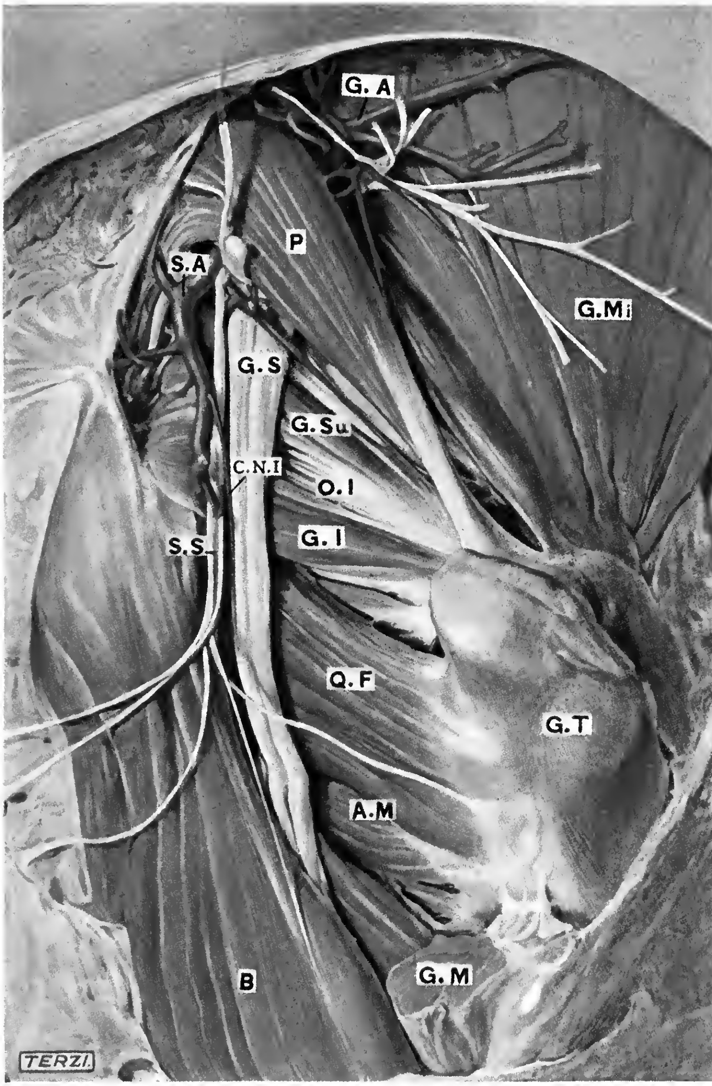

PLATE XXIV.—THE GLUTEAL REGION AFTER REMOVAL OF THE GLUTEUS MAXIMUS, SHOWING THE RELATIONS OF THE SCIATIC NERVE, ETC.

G.M., INSERTION OF GLUTEUS MAXIMUS. G.MI., GLUTEUS MINIMUS. P., PYRIFORMIS. G.SU., GEMELLUS SUPERIOR. G.I., GEMELLUS INFERIOR. O.I., OBTURATOR INTERNUS. Q.F., QUADRATUS FEMORIS. A.M., ADDUCTOR MAGNUS. B., BICEPS MUSCLE. G.S., GREAT SCIATIC NERVE. C.N.I., COMES NERVI ISCHIADICI ARTERY. S.S., SMALL SCIATIC NERVE. G.A. GLUTEAL ARTERY. S.A., SCIATIC ARTERY. G.T., GREAT TROCHANTER.

of the popliteal space, and at the lower margin of the popliteus muscle ends as the posterior tibial nerve.

The internal popliteal can be very conveniently reached through the incision made for ligaturing the lower part of the popliteal artery (page 407).

THE EXTERNAL POPLITEAL NERVE

Anatomy.—The external popliteal or peroneal nerve follows the outer side of the popliteal space, lying close to the biceps. Passing over the outer head of the gastrocnemius, between it and the biceps, the nerve reaches the neck of the fibula, and crosses that bone beneath the fibres of the peroneus longus muscle.

The nerve may be easily felt, when the knee is a little flexed, as a loose rounded cord, lying just behind the biceps tendon as it nears the head of the fibula.

Operation.—The patient lies upon the sound side, with a sufficient tending to the prone position to expose well the outer aspect of the knee.

The knee-joint is extended. An incision, one inch and a half in length, is made parallel with and immediately posterior to the tendon of the biceps. The cut should be so placed that its upper half is in relation with the tendon while its lower half is over the fibula. The skin and deep fascia having been divided, the biceps tendon is exposed.

The knee should now be a little flexed and the nerve sought close to the point at which the tendon reaches the head of the fibula.

A narrow and unduly prominent ilio-tibial band has been mistaken for the biceps tendon.

THE ANTERIOR CRURAL NERVE

This large nerve descends into the thigh in the groove between the psoas and iliacus muscles, and almost immediately below Poupart's ligament becomes flattened out and breaks up into numerous branches. The nerve is separated from the artery by the psoas muscle.

A vertical incision, two inches in length, should be made in the course of the nerve, and should commence a little above Poupart's ligament. In the superficial tissues of the region the crural branch of the genito-crural may be met with, and the superficial circumflex iliac vessels will cross the line of the wound. The fascia lata having been divided and the hip a little flexed, so as to relax the muscles, the nerve will be found without difficulty. The edge of the sartorius muscle need not be exposed.

THE INTERNAL SAPHENOUS NERVE

Anatomy.—This nerve can be most conveniently reached at the inner side of the knee opposite to the inner tuberosity of the tibia. When the long saphenous nerve leaves the femoral vessels it passes beneath the sartorius to the inner side of the knee, accompanied by the superficial branch of the anastomotica magna artery. Near the inner condyle of the femur the nerve gives off its patellar branch, which becomes cutaneous by piercing the fascia in front of the internal saphenous vein. The trunk becomes superficial opposite to the tibial tuberosity by piercing the fascia at the posterior border of the sartorius.

Operation.—An incision, about one inch and a half in length, made along the posterior margin of the sartorius opposite to the tuberosity of the tibia should bring the nerve into view.

The vein is an excellent guide to it, and as a rule the nerve will be found to be just posterior to the vein.

If the incision be made higher up, the patellar branch of the nerve—which lies in front of the vein—may be mistaken for the main trunk.

At the site of the operation some cutaneous arteries derived from the anastomotic will usually be found with the nerve.

The nerve is quite superficial at this point.

The vein when exposed should be gently drawn inwards.

PART VI.—AMPUTATIONS

CHAPTER I

GENERAL CONSIDERATIONS

THE history of surgical progress as regards amputations, though of undoubted interest, must be here dispensed with, as justice could only be done to it in many pages. Some modern writers even disparage the teaching of set forms of amputation such as are about to be described, but of their value there can be no doubt. To the free-thinking student it may be irksome to remember the names of Syme, Farabeuf, Spence, Lisfranc, and others in connection with definite forms of amputation at certain fixed parts of the limbs, and still more to have to learn the exact details laid down of each operation. But whilst it may be granted that the practical surgeon, in amputating a limb at any required point, will not always follow out to the letter the formal directions given in text-books, yet in many cases it is only by doing so that he will obtain a good result.

It is, for example, impossible to perform Farabeuf's amputation in the upper third of the leg or Syme's amputation at the ankle without having carefully studied the descriptions beforehand, and without having practised the methods on the dead subject. Throughout the whole range of amputations the surgeon must have certain guiding lines—which may at times be deviated from, according to the conditions presented by each individual case.

THE AMPUTATION STUMP

The success of any amputation or method of amputating is to be measured not by the rapidity or brilliancy with which the operation is performed, but rather by the mortality attending the procedure and the qualities of the resulting stump.

The importance of a sound stump, as far as it relates both

to the comfort of the patient and the utility of the mutilated limb, cannot be over-estimated.

1. **A good stump** is of regular outline, firm, solid, and insensitive. The scar is narrow, regular, and clean, and should be placed away from the point of greatest pressure.

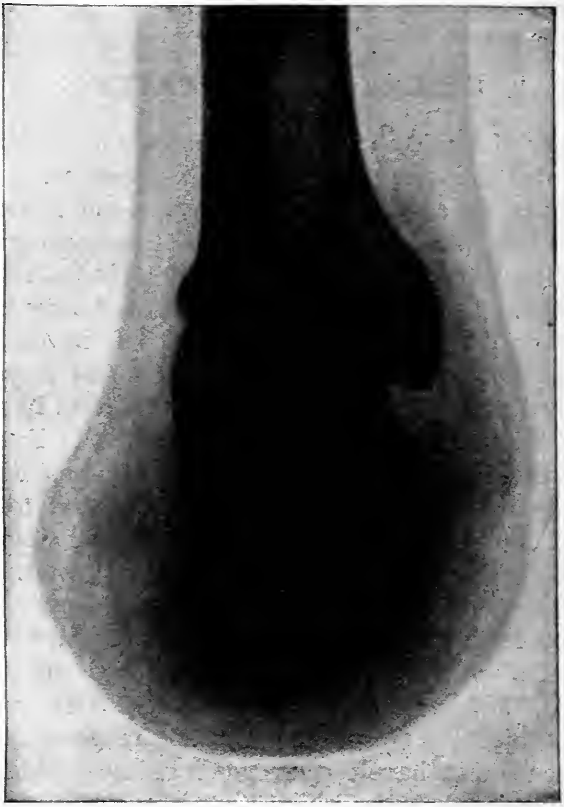

FIG. 351.—SKIAGRAPH OF STUMP RESULTING FROM SUBASTRAGALOID AMPUTATION, ILLUSTRATING THICK PAD COVERING THE BONE WHEREVER PRESSURE IS TRANSMITTED. FROM A CASE TWO YEARS AFTER AMPUTATION.

The *skin* is mobile, except at the site of the cicatrix; is well nourished, and capable of resisting pressure. Those stumps are the best, so far as the integumentary coverings are concerned, in which the skin over the more exposed parts is normally accustomed to pressure. Such stumps are illustrated by those in which the principal flap is derived from the sole of the foot,

the heel, the palm of the hand, the front of the knee, the back of the elbow (Fig. 351).

The *muscles* become atrophied, and their divided extremities are found to be embedded in a mass of sound fibrous tissue. Those whose functions are abolished are more or less entirely converted, in process of time, into connective tissue. Such as retain any capacity for action retain to a corresponding extent some muscular structure.

The divided *bone* becomes rounded off; the medullary canal is closed either by bone or by fibrous tissue. The extremity becomes either atrophied and pointed, or presents an abnormal enlargement due to a development of bone from the periosteum.

The new bone in some stumps forms a button or mushroom-like extremity for the shaft. In other instances the new bone formations are scanty and spicular, and play the part of foreign bodies in the stump. The nodular or pointed projection of the bone-end is chiefly met with after amputation through the growing limb of a young subject, and may necessitate one or more subsequent operations.

The whole shaft of the bone wastes. After an amputation through the knee, the femoral condyles may entirely disappear; and in an amputation above that joint, not only may the shaft and tuberosities become evenly atrophied, but this retrogressive change may extend to the pelvic bones of the same side.

After a disarticulation the *cartilage* left upon the bone atrophies and becomes fibrous, or entirely disappears in the course of years.

The *nerves* undergo a like atrophic process, so far as the motor and sensory fibres to muscles and skin below the site of amputation are concerned.

The divided extremities of the nerves may become enlarged and form considerable bulbous terminations. It may be here said, however, that this condition is not necessarily associated with tenderness of the stump (*see* page 462).

The *collateral circulation* is soon restored in the limb after the high division of the main artery. That trunk in time attains to such dimensions as are demanded by the vascular needs of the part. Some years after an amputation at the hip by an anterior flap, the portion of the femoral artery left in the stump

will probably be no larger than the radial. The wasting of the main trunk may be attended by an over-development of certain of its branches, so that after a lapse of time the principal artery may be difficult to identify on dissection.

2. **The bad stump** may owe its evil properties to many conditions. An amputation wound is liable to such ills as may attend the progress of any other extensive incision.

In dealing with this point it is necessary to exclude those diseases of stumps which depend upon an extension or a re-appearance of the original malady.

The skin may be scanty, thin, tightly drawn, unduly and unevenly puckered and adherent. The vitality of the integument may be so debased that the stump remains cold and purple, and liable to ulcerative changes which pathologically are allied to chilblains and the superficial gangrenous processes incident to the senile.

On the other hand, ulceration of a stump may appear to be due to such gross trophic changes that they are rather to be compared to the bed-sores of the paralysed or the "perforating ulcers" of locomotor ataxia.

The scar may remain weak, or become eczematous, or be, on the other hand, excessive, or take on the development of warty growths. The chronically inflamed and irritated cicatrix may become in time the seat of an epithelioma.

On the skin may form corns, or under it may develop bursæ.

The end of the divided bone may necrose, or the shaft may become inflamed.

The stump may be excessively tender, and the seat of continued pain. In some instances the pain is due to a slowly progressing periostitis or osteitis. In the greater number of examples it depends upon the compression of a nerve.

The nerve may be stretched over the extremity of the stump, or be exposed directly to pressure, or be the seat of actual neuritis. Its divided end may be compressed by the contraction of the mass of fibrous tissue in which it is embedded, or be irritated by a spicule or projecting mass of new bone.

On examining *painful stumps* by dissection it is common to find the ends of the divided nerves bulbous. There would, however, appear to be no essential or constant relation between

pain in the stump and a bulbous enlargement of the nerve ends. Such enlargements may be found in stumps which are insensitive and capable of bearing any reasonable amount of pressure, and may be absent in cases of painful stump. The examples of painful stump of less clear origin are ascribed to neuralgia when the patient is a male, and to hysteria when the patient is of the other sex.

One of the most common and most troublesome of bad stumps is that known as the conical stump.

3. **The conical stump** or sugar-loaf stump requires no description. The apex of the cone is formed by the extremity of the bone, which is not infrequently exposed and dead. The real conical outline is best seen in bad stumps following amputation through the arm or thigh, but all ill-covered stumps, such, for instance, as may be left after disarticulation at the knee or elbow, must be placed in the present category, although they may not assume the typical outline. (Fig. 352.)

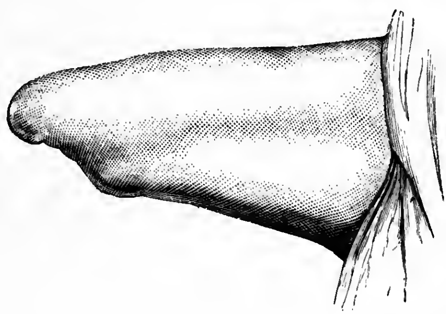

FIG. 352.—CONICAL STUMP FOLLOWING CIRCULAR AMPUTATION OF THE THIGH, AND DUE TO RETRACTION OF THE POSTERIOR AND INTERNAL MUSCLES. (*Farabeuf.*)

The following are the usual *causes of the conical stump* :—

(1) Too short flaps or too low division of the bone, whereby the soft parts when adjusted prove to be so scanty that the stump may be considered to be conical from the commencement.

(2) The more or less extensive sloughing of the flap, or the loss of a considerable portion of the soft parts by suppuration.

(3) The retraction of the muscles after the amputation has been completed. This retraction is a very common cause of conicity. A stump which at the time of the operation looked round and substantial may, as a result of slow and progressive retraction, become in time quite cone-shaped and useless.

This condition is most usually met with in amputation through very muscular parts and in muscular subjects. It is

common in the thigh and upper arm, and in the leg. In the latter situation it is due to the unequal and excessive contraction of the great muscles of the calf. (*See also* page 466.)

Rapid healing of the wound is the main opponent of secondary retraction of muscle. In most conical stumps the healing has been slow and the wound infected.

(4) Growth of the bone in young subjects. When an amputation has been performed on a young subject through one of the long bones, the epiphysial disc of growing cartilage above the point of section is not arrested in its action, and will continue to increase the length of bone in the stump out of proportion to that of the soft parts. The younger the patient at the time of operation the greater will be the tendency for a conical stump to develop subsequently. Thus, if the arm has been amputated through the upper third of the humerus in a child aged three or four, however long the flaps are cut, it is possible that repeated operations will be required to remove the projecting bone before epiphysial growth ceases at from 20 to 25 years.

The projecting bone is never of natural thickness, but tapers towards a slightly clubbed extremity. It is obvious that this cause of a stump becoming conical, unlike the ones previously mentioned, is not under the surgeon's control at the time of the first operation. Moreover, it is not always found. For example, in a case observed by one of us (J. H.) the patient had one thigh amputated through the centre of the femur by double-flap method at the age of five. When the stump was examined eleven years later there was not the least conicity, the growth of the muscles having kept pace with that of the bone. It is to be noted, however, that the upper epiphysis of the femur is of small importance compared with the lower one, so far as growth is concerned.

4. **Circumstances affecting the Contraction of the Stump Tissues.**—In planning the flaps for an amputation it is of the first importance that attention be paid to the normal contractility of the component skin and muscles.

(*a*) *The Skin.*—The contractility of the skin is considerable, but subject to much variation. It is practically lost in parts which have been long distended or long infiltrated. This is

well seen in the integuments about a tuberculous joint or a chronically inflamed part. The skin is apt to be loose in the aged and in those who have become rapidly thin, but at the same time it is found to have lost more or less entirely its retractile qualities.

It is needless also to point out the loss of contractility in skin which has become much atrophied or which has been long adherent to the deeper parts.

Other things being equal, the skin is most contractile in regions where it is thin, where the subcutaneous tissue is scanty in amount, where the integuments are not normally connected with deep aponeuroses or points of bone, and where it is but little stretched in any position of the limb. These regions are illustrated by the dorsal aspect of the wrist, the front of the bend of the elbow, the front of the forearm and arm, the district just above the ankle, and the region of the popliteal space.

Contractility is, on the other hand, least marked in parts where the skin is thick, where the subcutaneous tissues are considerable, where the soft parts are connected with deep fasciæ or points of bone, and where the integument is exposed to stretching in certain postures of the limb. These regions are illustrated by the palm of the hand and the sole of the foot, by the dorsal aspect of the finger-joints, by the soft parts in front of the knee and behind the elbow, and by districts in which the deposit of subcutaneous fat is considerable.

Speaking in general terms, the average contractility of the skin may be represented by one-third of the length of any given portion; that is to say, if a skin flap is required to be 8 cm. in length in order to cover the bone, its length before its separation should be 12 cm.

(*b*) *The Muscles.*—All muscles, of course, contract on division, but the extent of that contraction is subject to remarkable variations. Those muscles retract most which are quite free between their points of origin and insertion, and which are provided with long fibres, such as the sartorius, gracilis, and the biceps humeri.

These muscles may lose, according to Farabeuf, as much as four-fifths of their length on division.

Those muscles contract least which are provided with short

fibres, as illustrated by the penniform and bipenniform muscles; which are connected with bone at the seat of the division, as is the brachialis anticus; or which are attached to aponeuroses, as illustrated by the flexor muscles of the forearm just below the elbow-joint.

In a circular amputation at the middle of the arm the different degrees of contractility are well illustrated by the biceps on the one hand and the brachialis anticus and triceps on the other. An equally forcible comparison is provided in the calf, where the contraction of the surface muscles is measured against that of the deep. Muscular contraction is influenced also by the size of the muscle, by the amount of it left in the flap, by the age and death of the patient and the degree of his muscular development.

FIG. 353.—STUMP OF RIGHT ARM AFTER AMPUTATION BY TWO EQUAL LATERAL FLAPS. THE GREATER RETRACTION OF THE INNER FLAP HAS DRAWN THE CICATRIX TO THE INNER SIDE. (*Farabeuf.*)

It is impossible to gauge the contraction which will take place in a young, vigorous, and athletic man by that which is observed when the same muscles are divided in an aged, cachectic, or bed-ridden subject.

The muscles to be divided may have become atrophied, or may be infiltrated with inflammatory material or by a new growth, or may have already become fully contracted from a long-continued, fixed position of the limb.

In addition to the immediate contraction of a divided muscle, there is also the secondary retraction which follows slowly. This secondary retraction is, of course, influenced by the conditions already detailed, but it depends probably to a much greater extent upon the circumstances of the healing process.

Stumps in which, at the time of the operation, a very liberal provision for the covering of the bones was made, may become in time conical if the healing process be ill-conditioned and much prolonged. The main preventive of secondary retraction of muscles is rapid and sound healing.

Considering the contractility of all the soft parts together (skin and muscles), Farabeuf lays down the following *rules:*

(1) The primary or immediate retraction of the tissues forming a flap may be represented by one-third of the length of that flap; i.e. if a flap of 10 cm. is required to cover the bone, it should be cut 15 cm. long.

Additional length must be given to the flap—

(*a*) When the section of the bones is large compared with the section of the soft parts—as in an amputation just above the wrist, or through the leg (in a thin subject) a little below the knee-joint.

(*b*) When secondary retraction is to be feared.

(*c*) When the amputation is performed at some distance from the root of the segment of the limb concerned. In such case all the muscles in the flap are cut at little less than full length. Thus, other things being equal, the flaps should be proportionately longer in an amputation just above the wrist than in an amputation just below the elbow, the same muscles being involved in both cases.

(2) The integumentary part of the flap should always be cut longer than the muscles, and those muscles which lie deeply around the bone somewhat shorter than the more superficial ones.

The effects of the retraction of the tissues after operation upon the outline of the wound vary in different parts. Thus a circular incision at the wrist becomes an elliptical incision with the highest point posterior, in consequence of the undue retraction of the dorsal integuments. A circular wound about the centre of the forearm remains circular, since the parts contract equally. A circular incision at the elbow becomes elliptical with the highest point anterior, owing to the undue contraction of the soft parts in front of the joint. A circular wound in the thigh takes an elliptical outline with the highest point postero-internal. It has therefore been said by Marcellin Duval, "To carry out the circular method in the thigh, one must practise the elliptical incision."

The contraction of the tissues of a flap may be very unequal, owing to local changes in the part of the limb involved.

5. **Circumstances affecting the Vitality of the Stump Tissues.**—The vitality of a stump, and as a consequence its disposition to heal, depend mainly upon the character of its blood supply.

If a large fleshy or cutaneous flap be cut containing an insufficient number of uninjured arteries to meet its nutritive needs, it is obvious that no skill in operating, and no care in the after-treatment, can save some portion of the flap at least from destruction. This is one drawback of the method by long hooded flaps used at the knee-joint (Stephen Smith's amputation).

In fashioning the heel flap in a Syme's amputation at the ankle a very slight deviation of the knife will at once deprive the flap of one-half of its proper blood supply.

In like manner, in the amputation at the place of election in the leg by Farabeuf's method the single external flap is admirably well nourished so long as the artery embedded in it remains intact; but if by any unfortunate movement of the knife the vessel is divided at the last moment at the base of the flap, no skill can save its tissues from some loss by sloughing. Moreover, a well-nourished flap may be rendered anæmic by the compression of bandages, or by its being too tightly fixed to a supporting splint. The same effects—but in less degree—may follow the bending of the integuments over the bone. Such bending may compress the vessels of the flap to a dangerous degree, especially when the part is much drawn upon by tight sutures.

In considering this effect note must be taken of the natural disposition of the parts. For example, after a disarticulation at the knee-joint by a long anterior flap the skin is in its normal position when it is folded over the femur, and no undue compression of the vessels will occur. But in a disarticulation at the same place by a single long posterior flap the tissues of that flap are so bent over the condyles of the bone as to cause the contained vessels to be very easily occluded. Undue traction upon a flap must in almost every amputation tend to diminish its blood supply. Stumps left after Teale's method has been adopted have the disadvantage that the long flap is bent back upon itself and its blood supply thus impeded.

In fashioning skin flaps, care must be taken that they are not too scantily cut, and that the skin itself is not separated from the subcutaneous tissues.

The blood supply of the skin—from the point of view of flap formation—varies in different parts of a limb, and is most

efficient in the region of the joints. The largest skin flaps possible in amputation may be cut from the front of the knee or the back of the elbow. Flaps of corresponding size separated from the segments of the limbs above and below these joints would in all probability perish from malnutrition.

Long tendons and loose aponeuroses should not be left in a stump. Their vitality is low, and they show a great disposition to slough.

The bone in the amputation stump occasionally becomes necrosed. This may be due to rough handling of the bone, to extensive damage to the periosteum, or above all to infection of the wound. But, with reasonable care in clearing the bone (*see* page 482) and in obtaining aseptic healing, necrosis ought never to occur.

The other circumstances influencing the vitality of flaps are more or less general, and need not be considered in detail. Among them are the health and condition of the patient, the state of the limb previous to amputation, the manner in which the operation is conducted, and the treatment of the wound carried out.

6. **Situation of the Cicatrix.**—The utility of a stump depends to no small extent upon the position of the cicatrix. It is important, when possible, that the cicatrix should be so placed as to be the least exposed to pressure.

In this connection it must be borne in mind that the function of a stump in the lower extremity is very different from that of a stump in the upper limb. The former should be capable of withstanding pressure and of bearing weight upon its extremity. The scar, therefore, will be least well placed when it is "terminal," or situated upon the point or summit of the stump. It will be most conveniently disposed when it is "lateral," or placed upon one of the sides of the stump.

On the other hand, in the upper limb the stump is not required to bear weight or to withstand pressure upon its extremity. The pressure will most usually come upon the sides or circumference of the stump. This is seen in noting the movements of an artificial arm—e.g. after an amputation above the elbow—when the limb is passed in various directions. As the apparatus is placed in one or other attitude the stump which

directs it will receive pressure on its "sides," but not upon its extremity or terminal point.

In a general way, therefore, it may be said that the position of the cicatrix which is best adapted for stumps of the upper limb is least adapted for those of the lower.

Some stumps, of course, require quite special support, and some artificial limbs can be worked independently of any assistance from the actual stump itself.

If a "peg-leg" be employed after an amputation at the place of election, the position of the cicatrix is a matter of not the least importance.

CONTROL OF HÆMORRHAGE DURING THE OPERATION

In the case of many minor amputations no special precautions are required, the arteries being seized with Wells' forceps as each is cut through. But in the case of the larger operations it is most important to diminish the loss of blood and thereby the amount of shock incurred by the patient.

Three chief methods are now employed:

1. Digital or instrumental compression of the main artery of the limb above the site of amputation. This, of course, only lessens the bleeding, it cannot wholly control it. It is, however, specially applicable in certain regions. Thus the common femoral may be firmly compressed against the pubes and the subclavian against the first rib. Sir W. Macewen has advocated compression of the abdominal aorta by the hands of an assistant during amputation at the hip. Compression of the main artery by means of a sharp skewer which is passed through the limb and underpins the vessel has found advocates, but this method is, we think, rarely advisable.

2. Esmarch's elastic tourniquet. Where this can be employed it gives very good results provided that the following points are attended to.

> 1. Preliminary compression of the whole limb by the elastic bandage is unnecessary in most cases, and dangerous in some, e.g., cases of suppuration or gangrene of the limb to be amputated.
>
> The limb should simply be raised vertically for a few minutes before the tourniquet is applied.

2. The tourniquet is placed over a folded towel which encircles the part well above the site of operation. This prevents nipping of the skin between the loops of the tourniquet.

    Sufficient pressure must be employed to arrest completely the arterial flow.

3. Directly the amputation is finished the main arteries must be sought for on the face of the stump and secured with Wells' forceps and ligatures. The tourniquet is then promptly removed.

3. Preliminary ligature or clamping of the main afferent vessels. Thus the subclavian artery and vein are tied before amputation of the upper limb with the scapula, the common iliac artery may be clamped before amputation at the hip-joint.

Finally it may be noted that the apparatus for infusion of saline solution should be got ready before proceeding to any amputation likely to be attended with much loss of blood or shock. Thus in amputation of the hip saline infusion into a vein of the patient's arm may be carried out whilst the operator is at work.

THE INSTRUMENTS REQUIRED IN AMPUTATION

The amputating knife must necessarily vary according to the character of the operation. The great alterations made in recent years in the mode of performing amputations have had an equally pronounced effect upon the chief instrument. The enormous knives employed some thirty or forty years ago have ceased to be used. For an amputation at the hip-joint in Fergusson's time a knife with a cutting edge of from twelve to fourteen inches was employed. At the present day that operation is commonly effected with a knife no larger than the instrument used for excising a breast.

All knives used in aseptic surgery should be made with blade and handle of the same piece of steel, since they are so easily cleansed or sterilised (Fig. 354).

With regard to the length of the blade, it must be remembered that, when force and precision are required, the blade must be short, and the handle large and strong. This is well illustrated by Syme's amputation, for which operation no instrument is better suited than an old knife, the blade of which has been shortened and narrowed by repeated "settings."

For transfixion operations the length of the blade should be equal to that of one diameter and a half of the limb, and the same rule applies roughly to the knife required for the circular operation.

Over these long blades the operator has little control, as will be shown if he attempt to complete a transfixion or circular amputation with the long knife used at the commencement of the operation.

In performing an amputation at the hip by antero-posterior flaps cut by transfixion, the point of the knife has been thrust into the

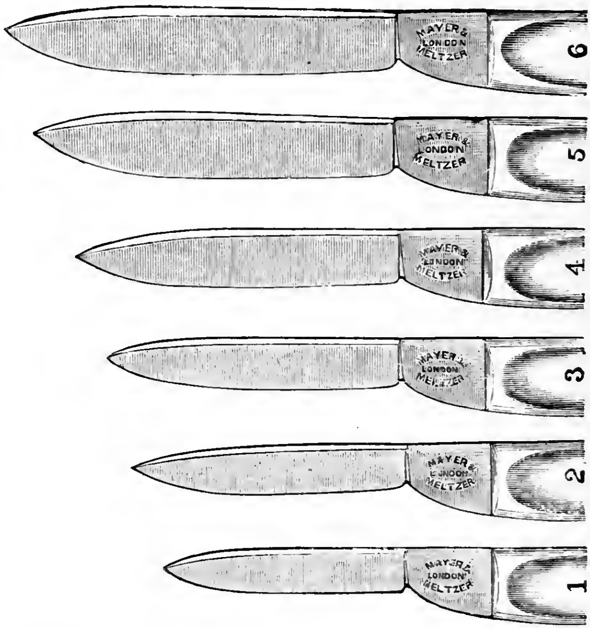

FIG. 354.—KNIVES MADE WITH THE HANDLE AND BLADE OF ONE PIECE OF STEEL. With these most amputations can be done, though where transfixion of a thigh or arm is employed a much longer blade is required.

femur and broken against that bone, and has found its way into the thyroid foramen, into the scrotum, and into the thigh of the opposite side.

In a good amputating knife the blade is light and narrow, and the back not too heavy. The point of the knife is nearly lancet-shaped.

In the smaller knives—such as are adapted for cutting flaps from without inwards—the point may be a little nearer to the dorsum than to the cutting edge, and the edge itself may be a little rounded. Fig. 355 shows an amputating knife with almost every bad quality—

a long knife with a small, weak, smooth handle ; a blade with a heavy back, a projecting heel, and a tapering and fragile point. The instrument styled in instrument-makers' catalogues "a metacarpal knife" may be taken to represent the worst form of knife that could (within reasonable limits) be used for amputating a finger at a metacarpal joint or for removing a metacarpal bone. The immense broad-bladed knives figured by some authors as adapted for amputation by the circular method belong to a past age. The catlin, or double-edged knife, has now fallen into disuse. No such instrument is required to divide the soft parts between the tibia and fibula. The knife is not only quite unnecessary in any amputation of the leg, but in the hands of the inexperienced is dangerous. A useful instrument in all amputations is a good stout scalpel with a substantial handle.

The amputating saw should be broad and long in the blade and have fine teeth. The blade is about ten inches in length and

FIG. 355.—AMPUTATION KNIFE WITH EVERY BAD QUALITY.

two and a half inches in width. Those with movable backs are the most convenient, and enable the sawing edge to be reduced to the narrowest possible dimensions. The bow saw, Farabeuf's, or Butcher's saw, is best adapted for amputations in which a curved or oblique division of a bone is desired.

Many **retractors** have been devised for the purpose of protecting the soft parts during the application of the saw. The simple linen two-tailed retractor answers well enough. The fingers of one or more intelligent assistants answer better. A three-tailed linen retractor may be used in amputations through the leg and the forearm. Three ivory spatulæ placed close to the bone, and made to cross one another in the form of a triangle, represent an admirable retractor.

The other instruments used call for no especial comment.

The following is **the list of instruments** which may be required in the performance of an amputation :—

Amputating Knives.
Stout Resection Knives.
Scalpels.
Saws.
Lion Forceps.
Bone Forceps.
Rugines.
Linen Retractors,
Ivory Spatulæ.
Dissecting and Wells' Artery Forceps.
Scissors, Needles, Ligatures, Sutures, Dressings.
Splint or Support for the Stump.

METHODS OF PERFORMING AMPUTATION

The following are the principal procedures in amputation :—

1. The Circular Method.
2. The Modified Circular Method.
3. The Elliptical Method.
4. The Oval or Racket Amputation.
5. The Amputation by Flaps.

1. **The Circular Method.**—In this method of amputation the soft parts are divided by a series of circular cuts, made from the skin down to the bone. The tissues are not divided by one sweep from integument to periosteum, but by a number of successive cuts, in such a way that the skin and the layers of muscle are severed at different levels.

Two forms of circular amputation are practised at the present day. They are identical in principle, and their differences, such as they are, depend upon anatomical features, and are indeed influenced only by locality.

(1) The ordinary circular amputation—the *amputation circulaire infundibuliforme* of the French—is illustrated by an amputation through the arm or thigh. In these parts the bone is more or less evenly surrounded by thick muscles. After each circular cut the soft tissues are allowed to retract, or are retracted, before a second sweep is made with the knife. The result is that the wound becomes funnel-shaped ; the edge of the funnel is formed by the divided skin ; the apex of the funnel, or infundibulum, by the divided bone.

In performing a circular amputation the surgeon stands to the right-hand side of the limb to be removed, i.e. to the outer side of the right upper or right lower limb, and to the inner side of the left limbs. The operator is thus able to grasp the limb above the site of the amputation with his left hand. In removing the left arm it may be more convenient to stand to the outer side of the extremity.

The precise position of the circular incision below the level of the future saw-cut must vary with the site of the amputation and the condition of the limb. It is indicated in the descriptions of the particular amputations.

In later chapters illustrations of the ordinary circular amputation are afforded by an amputation of the arm (page 536) and an amputation of the thigh (page 652).

(2) The circular amputation *à la manchette* is adapted for parts where the covering of the bones is scanty and is composed of irregular

tissues. Such a region is best illustrated by the wrist, where the bones are surrounded by many tendons, and where muscular tissue is scanty and unevenly disposed.

In this method of amputating, the skin and subcutaneous tissues are turned up in the form of a cuff, or *manchette,* and are turned back like the cuff of a coat. The skin is divided, as in the previous operation, by circular incision, and is then, together with the subcutaneous tissues, turned back as shown in Fig. 356. The turning back of this cuff is mainly effected by the fingers of the surgeon's left hand. The

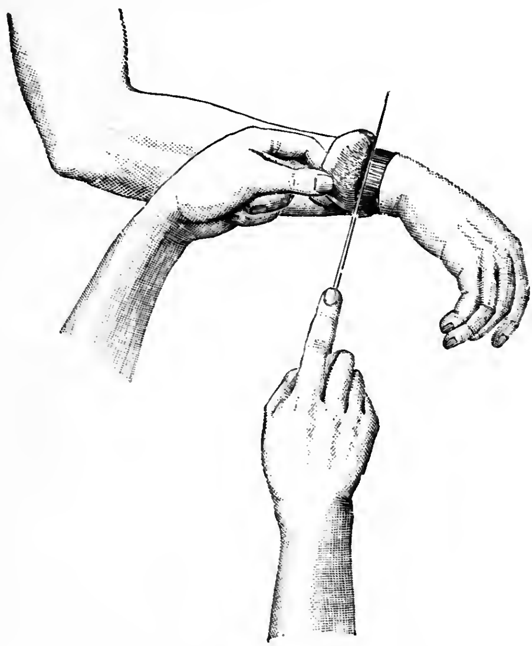

FIG. 356.—CIRCULAR AMPUTATION *À LA MANCHETTE.*

skin is freed by the knife, which should always be held perpendicularly to the surface. The cuff is not *dissected* up. It is gently freed and turned up. If the knife be passed obliquely beneath the skin which has to be everted, the skin is apt to be needlessly damaged. The cuff must be even and regular, and of a size previously determined upon. The soft parts are then divided by a circular sweep, with the knife at the level of the retracted and everted skin. Only one such incision will probably be necessary.

2. **The Modified Circular Method.**—Three important modifications need to be described :

(1) In addition to the circular cut through the integuments, a vertical incision is made to join the original wound. The skin on either side of this vertical cut, and at the points where the cut joins the circle, is then reflected in the form of two imperfect skin flaps. This modification is illustrated by one form of supramalleolar amputation (page 610).

(2) Two vertical incisions are made to join the circular wound. By this use of the knife two square skin flaps can be dissected up, and the muscles, when exposed, can be divided by a circular sweep of the knife. This plan also is described among the supramalleolar amputations.

(3) The modification suggested by Liston, and extensively practised by Syme—with whose name the method is associated—is strongly recommended by many surgeons of the present day. Two very short flaps, of semi-lunar outline and of equal width and length, are dissected up. They are composed simply of the skin and the subcutaneous tissues, and consist of little more than curved incisions made across opposite surfaces of the limb, each being equal to one-half of the circumference of the limb.

The skin beyond the bases of the little flaps is then retracted as a whole, just as in the usual circular amputation. When the retraction has been carried to a sufficient extent, the muscles are divided by circular incisions in the usual way. This method is illustrated by an amputation of the thigh (page 654).

3. **The Elliptical Method.**—This operation was adopted by Sharpe, of Guy's Hospital, as an improvement on the circular method, in the middle of the eighteenth century. It is sometimes described as a variety of the oval method. It occupies an intermediate position between the circular operation and the amputation by a single flap.

The incision in the skin is elliptical or lozenge-shaped (*le mode losangique*). The position and inclination of the ellipse vary according to the site of the amputation, and have to be carefully estimated (*see* Disarticulations at the Elbow-joint). The skin and subcutaneous tissues are then retracted, by gliding, as in one amputation at the wrist (page 512), or by the turning up of a cuff, as in the disarticulation at the elbow by a posterior ellipse (page 532), or by the separation of a definite flap, as in Guyon's supramalleolar amputation (page 608). The muscles are usually divided as in the circular operation. They may be, however, cut in part by transfixion, as in the disarticulation at the elbow-joint by an anterior ellipse. The elliptical method is well adapted for amputations through certain joints, and is illustrated in later sections by the operations just alluded to.

4. **The Oval** or **Racket Method.**—In this operation the skin incision takes the form of an oval with one end pointed, or of an isosceles triangle rounded at its base. The edges of the resulting wound are united in its long axis. The soft parts beneath the skin are divided down to the bone by cutting from without inwards.

To obtain a better exposure of a joint without loss of substance, and to afford a better covering for the bone in the upper part of the wound, Malgaigne extended a longitudinal cut from the apex of the oval, producing thus *l'incision en raquette*, the longitudinal wound forming the handle of the "racket."

In this category is placed also the **T**-shaped incision—an incision formed of a circular cut joined by a longitudinal one. The racket and **T**-shaped incisions are best illustrated by disarticulations at the metacarpo-phalangeal and metatarso-phalangeal lines of joints (Figs. 363 and 380). Amputation by the racket incision is also illustrated by certain disarticulations at the shoulder- and hip-joints.

5. **The Flap Method.**—The methods of performing amputation by means of flaps are numerous and varied, and have been subjected from time to time to so many modifications and re-modifications that a systematic classification of flap methods is scarcely possible.

Skin Flaps and Muscle Flaps.—Any flap or flaps may be composed of the integuments only, or of the integuments and the subjacent muscular tissue. Some difference of opinion has existed as to the merits of skin flaps and muscle flaps.

In every flap the skin must be cut longer than the muscle tissue. A flap containing too much muscular tissue is unwieldy; it is difficult to adjust, and the muscle is certain to protrude. In endeavouring to bring the edges of the skin together, undue strain is apt to be placed upon the sutures. Much of the muscle tissue, being far removed from its blood supply, may slough. If, however, the part heals well, the resulting stump is firm and well-rounded, and the end of the bone is well covered.

A flap composed of skin only is very apt to slough. This tendency is least observed in the integuments about joints, where the vascular supply of the skin is derived from many channels; elsewhere an extensive skin flap is very liable to perish for lack of blood. The skin flap is easily adjusted and falls readily into place. It affords, on the other hand, but a slight covering to the bone and a scanty protection to the stump. The skin, however, in some regions is accustomed to withstand pressure, and affords an excellent covering for the stump. Such regions are illustrated by the heel, the front of the knee, and the back of the elbow.

In general terms, it may be said that the best flaps are those which contain muscular tissue, provided always that the skin covering the stumps be longer than the divided muscles which it contains. The amount of muscle contained in the flap must depend upon the situation of the amputation, the contractility of the divided muscles, and the covering required for the bone. If it be considered desirable that a flap should contain a main artery, this cannot be effected unless a muscular flap be dissected up.

SELECTION OF METHODS OF AMPUTATING

In selecting a specific method for performing an amputation respect must be had for the adage that "the coat must be cut according to the cloth." Each case must be taken upon its merits, and regard be observed for the structural condition of the limb. A method well adapted for a stout or muscular subject in the prime of life may not be suited for an identical operation when performed upon a much-wasted, aged, or cachectic individual. In performing a circular amputation, retraction of the skin may be rendered difficult by reason of existing œdema or induration; or the integuments may have been rendered rigid and adherent by a long-abiding inflammation. The muscles also may not contract when divided; they may be found atrophied, or converted into fatty or fibrous tissue, or matted together by inflammation, or paralysed from disease or disuse. Flaps likewise may have to be modified to avoid diseased districts, ulcers, sinuses, and the like. The skin and muscles may not contract on division. The muscular tissue may be so atrophied that scarcely enough remains to form the substance of a substantial flap. The main artery of the limb, or the vessel which is to form the principal artery of the flap, may be found to be occluded and the circulation to be diverted into many collateral channels. In such case the main vessels may scarcely require a ligature, while hæmorrhage will occur from a number of divided arteries anatomically insignificant.

In the comments upon the various methods of amputating described, the comparative value of each procedure is discussed.

The main points to be considered in *the selection of a method* are the following:—

1. The least sacrifice of the healthy tissues of the limb.
2. The providing of a good and permanent covering for the bone.
3. The obtaining of as small a wound area as is consistent with the proper performance of the amputation.
4. The securing of a good blood supply for the flaps or tissues which will form the stump.

5. The production of a well-adjusted cicatrix, and one so placed as to be removed from pressure when the stump has healed.

6. The ease with which the bone can be exposed at the saw-line, and the general simplicity of the method.

7. The cutting of the main vessels transversely.

8. The rapidity with which the amputation can be performed.

The last point, which was at one time almost the most important, is now one of the least to be considered. Before the days of anæsthetics, speed was the primary good quality in any amputation method, and it was customary to estimate the value of a procedure, first of all, by the number of seconds or minutes involved in the removal of the limb.

Chloroform and ether have entirely changed this ground for criticism—wider issues are now concerned; the minimum sacrifice of parts, and the well-being and utility of the stump, are now primary considerations, and amputations are effected with some of the care and precision which characterise the plastic operations of surgery.

The *elliptical* and *oval* methods require no further consideration. They are founded upon the circular operation, are of limited application, and are admirably adapted to the parts in which they are practised. *In comparing the circular and flap methods* one conspicuous consideration, is the resulting wound area. The investigations of Farabeuf show that in a limb with a diameter of 10 cm. the wound area (*la surface saignante*) of the stump will be 110 square cm. after both the ordinary circular amputation and the amputation by two equal rounded flaps, and will be 125 square cm. after an amputation by a single rounded flap.

The *circular operation* provides, then, a small wound surface. It involves the least sacrifice of the healthy limb; it is easily performed; the blood-vessels and muscles are cut cleanly and transversely, and the soft parts covering the bone are well supplied with blood. On the other hand, the operation cannot be well performed without an assistant; the exposure of the bone at the saw-line is not always effected with ease and without undue disturbance of the soft parts, and the edges of the wound do not fall easily together. Moreover, in muscular limbs the after-retraction of the divided muscles is apt to lead to a conical stump. Indeed, one of the most common examples of such a stump is provided by carelessly performed circular amputations of the thigh in muscular subjects. In wasted individuals, and under conditions where muscular retraction is inconsiderable, this objection does not hold. The circular method is not adapted for cases of injury or disease when the parts near the site of the amputation are unequally involved.

The *flap method*, as represented by flaps cut either from without inwards or by dissection (*see* page 478), is capable of adapting itself to many conditions and to any part. It is particularly valuable in instances of unequal destruction of the parts of a limb. The area of the wound surface may be, as already pointed out, larger, and, other things being equal, it may be allowed that the flap operation involves a greater sacrifice of tissue than does the circular. The blood-vessels may be cut obliquely, and may even be slit up. The muscles are divided obliquely. In long flaps there is a danger of their tissues perishing from an insufficient blood supply. The operation is in some forms difficult, but can usually be performed with less skilled assistance.

On the other hand, the bone at the saw-line can be readily exposed; the flaps fall easily together; the site of the future scar can be modified as required; the coverings of the stump can be fashioned so as to meet the varying conditions of the limb, and the development of a conical stump can be more surely avoided after a flap amputation than after the circular operation.

As to the cutting of the flaps themselves, the methods by cutting from without in and by dissection are, beyond doubt, the best. Flaps so fashioned can be formed with great precision. The proportion of contained tissue can be determined with accuracy, and the exact relations between the amount of skin and of muscle covering the bone can be regulated with ease. Main vessels need never be slit up, and, indeed, under many conditions these structures may be exposed and secured before division. By these methods also the smallest possible section of muscles can be accomplished.

Some part of a flap may be conveniently cut by transfixion, as in Hey's amputation through the middle of the leg, and the disarticulation at the elbow-joint by the elliptical method. The part so divided must belong to the muscular portion of the flap.

The cutting of a large flap by transfixion alone, in such a way that the knife divides both muscles and integument at one sweep, is to be strongly condemned. The method has one recommendation only—it is rapid.

If the rapidity with which a limb can be removed should prove in any case to be a matter of the first importance, then the amputation by flaps cut by transfixion may be entertained. Such operations are described in connection with amputations of the thigh and disarticulations at the hip-joint.

The following objections are to be urged against the transfixion method: The surgeon has little control over the large knife he must

employ. The flaps cannot be cut with precision, nor can their thickness be very accurately gauged. The skin is divided together with the superficial layer of muscular tissue. The muscles themselves are cut obliquely. The main vessels may be transfixed, or may be cut unduly short, or may be sliced up. Much tissue at the bases of the flaps escapes division, and requires to be cut before the bone can be cleared for sawing.

The method belongs to the past, to a period of "brilliant" surgery, when the shrieking and terror-stricken patient was held in the amputation-chair by many lusty assistants, and the operator's pupil stood by with a fob-watch in his hand.

GENERAL POINTS IN THE PERFORMANCE OF AMPUTATIONS

1. **The Handling of the Knife.**—It is needless to point out that an amputating-knife is a powerful instrument, with the edge of a razor, and that it must be wielded with infinite care and precision. It is a dangerous instrument in the hands of the surgeon who believes that limbs should be "slashed off," and that an operator's ability is to be estimated by the number of seconds involved in the procedure. Flaps should be planned with the minutest care, and it is better that the lines of the intended incisions should be marked upon the limb in crayon before the operation than that the surgeon should trust to his eye and the hope that "the flaps will come together." Each incision should be made deliberately, and should be final.

The "trimming" of flaps is usually an evidence of incompetence.

The greatest possible care should be taken of the principal arteries, lest the stump be left anæmic. In the hasty and careless cutting of flaps, especially by transfixion, it is very easy for the main artery of the part to be slit up or divided at too high a level.

Nerves and tendons should be cut short; arteries long. In dividing tendons a sharp, vigorous cut is needed, and the tendon should be put upon the stretch at the time the knife is applied. If after the limb be removed any tendons are left "long," i.e. hanging from the surface of the stump (as may occur after Syme's amputation), they should be seized with sharp-pointed forceps, put on the stretch, and divided by strong scissors. Loose tendons are not readily severed by a knife.

2. **The Handling of the Saw.**—Care should be taken, in the first place, that the bone is not bared too high above the site of the future saw-line.

If a *periosteal flap* is to be made, this membrane itself should not be actually exposed. A flap large enough to cover the divided end of a bone, and composed solely of periosteum, is probably useless and destined to perish.

The flap should contain not only the periosteum, but the deepest muscular layers about the bone. These two tissues should be separated from the bone together. It is through the muscular tissues that the blood-vessels reach the periosteum.

The value of the periosteal flap has not yet been clearly demonstrated in all cases, and it may be a question whether it is always worth the time involved in its production.

In using the saw, the first care is to make a groove on the bone in which the saw shall run smoothly, without risk of slipping and damaging the soft parts around.

It is well to fix the thumb-nail of the left hand into the bone just above the saw-line, while the blade of the saw is rested and steadied against the knuckle of the thumb.

The saw should be held quite lightly at first, and should be drawn from heel to point in making the groove. The bone can then be divided by long, firm, slow cuts.

The whole length of the saw-blade should be used. The hand should be light. Rapid sawing is unnecessary, as is also the use of large and coarse-toothed saws. As the division of the bone approaches completion the strokes made with the saw should be short and again very light.

When two bones require division, a good groove should first be made in the larger one, and when the saw has obtained a sure hold its edge can be dropped upon the smaller bone. The division of the smaller or more movable bone should be completed first. Special methods for dividing the tibia and fibula are described in the account of Farabeuf's amputation of the leg at the "place of election" (page 621).

Every care should be taken that the soft parts are well protected during the process of sawing. The assistant who holds the limb should hold it horizontally and at right angles to the saw-blade. If the limb be held too high or too low, or be not properly supported close below the site of the amputation, the saw is apt to be locked, or the bone to break before its division is completed. The assistant should draw the limb away from the trunk, while at the same time he supports it efficiently. Any splinters of bone should be removed with bone-forceps.

The division of small bones, such as those of the fingers or meta-

carpus, by bone-forceps is to be condemned. By such division the bone is crushed and splintered, and needlessly damaged. This is especially the case with the bones of well-developed adults and of aged persons. The division of these slender, long bones is best effected by means of a very fine saw, and for the purpose the smallest form of bow-saw answers admirably. The not infrequent separation of spicules of necrosed bone after amputations of the fingers and toes is probably often due to the splintering and crushing of the bones produced by the bone-forceps. The forceps effect the division of the shaft speedily, but at a great sacrifice, and their use is opposed to one of the first principles of surgery.

3. **Arrest of Bleeding.**—After the bone has been sawn, the stump should be supported by an assistant, who can at the same time hold up any flap and generally do his best to expose the whole surface of the wound.

The main vessels may have been secured before or during the fashioning of the flaps. In the majority of cases, however, this is not done. The surgeon and his assistants, the moment the wound surface is well exposed after the amputation, should seize all the visible divided arteries with pressure-forceps. The operator should secure the principal vessels, while one or more assistants grasp any minor trunks which may be noticed.

During this preliminary securing of the severed arteries, the tourniquet is still applied or pressure upon the main vessel still maintained by the assistant who is responsible for the control of hæmorrhage during the amputation.

While the ligatures are being applied the stump should be supported in an elevated position. In the case of the upper limb an assistant can readily effect this. After an amputation of the lower limb the stump should be supported upon a glass block similar in shape to those used in dissecting-rooms to receive the head of the subject. By this means the whole area of the wound is well exposed to view, the stump is kept perfectly steady, and is maintained at a convenient elevation.

The tourniquet having been removed, or pressure upon the main artery relaxed, any smaller bleeding points are secured with clamp-forceps. The cut vessels are finally closed in the manner already described, some by pressure merely, some by torsion, the remainder by ligature. It is necessary that a ligature should be placed upon the main vein, or upon any other vein from which blood continues to ooze.

Persistent bleeding from the sawn surface of the bone may usually

be checked by gentle pressure maintained for some time with a piece of sponge.

Bleeding from a distinct artery in the bone seldom calls for further means than these. Should it, however, be maintained, an attempt should be made to separate the coats of the vessel from the wall of the bony canal by means of a fine needle, and then to force them, when separated, into the canal so as to form a kind of natural plug. I have never met with a case which called for the use of "the sharpened end of a wooden match" as a plug. This plug, which so many authors allude to, is probably intended to be no more than a picturesque example of fertility of resource.

4. **Closure of the Wound.**—The cleansing of the wound surface and the application of the sutures are conducted in the manner already

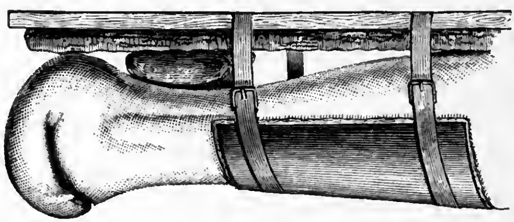

FIG. 357.—SUPPORTING SPLINT ADJUSTED TO THE LEG AFTER CHOPART'S AMPUTATION.

described (Vol. I., page 71). There should be no tension upon the wound, no dragging of the flaps together, no attempt to cover the bone by traction upon the soft parts. The edges should fall together. To unite the wound a long, straight needle is employed, and the best suture material is silkworm gut.

If the sutures are applied at a proper distance apart, and if firm and even pressure is employed, so as to approximate the wound surfaces and obliterate any cavities or pockets between the flaps, no drainage-tubes may be required. If a sinus has been exposed during the amputation, and has been scraped out, a plug of gauze may be allowed to occupy its cavity for a day or so. If the knife has passed through œdematous tissues, much oozing must of necessity occur after the operation, and to allow this to have free exit a tube may be employed for 24 or 48 hours. In any case of doubt a tube (to be retained for 24 or 48 hours) should be inserted.

The stump must be properly supported after the operation, and care exercised that all traction is, as far as possible, taken off the flaps. In a large proportion of the cases of amputation the support of a splint is required. The splint serves to support the flaps, to maintain the

limb at rest, and to favour the application of such pressure as is required (Fig. 357). This figure is purely diagrammatic, as the necessary dressing has been omitted. For the comfort of the limb a copious layer of cotton-wool would be required to envelope it.

More specific details as to the after-treatment of amputation wounds are given in the chapters which follow.

THE MORTALITY AFTER AMPUTATION

1. **General Mortality.**—Since the introduction of improved methods of performing amputation and of treating wounds, the general mortality after the operation has been very considerably reduced.

The more voluminous statistics published are of little value at the present day, since they deal with data afforded by older and much less successful forms of practice, and are largely composed of the returns of army surgeons. It is noteworthy also that the results shown by different statistics vary considerably.

Schede has compiled a table of 321 cases (occurring in civil practice) of amputations performed antiseptically, and attended by a mortality of only 4·4 per cent., while in 387 cases of amputation of equal importance treated during the pre-antiseptic period the mortality was 29·18 per cent. The statistics of the Newcastle-on-Tyne Infirmary, as prepared by Mr. Page, give, in ten years ending December, 1888, 484 cases of amputation, with a general mortality of 7·6 per cent. (*Lancet*, July 13th, 1889.)

The statistics of St. Thomas's Hospital for the ten years 1876-1885 give a mortality of 12·8 per cent. for amputations of all kinds performed during that period. The statistics of 400 cases of amputation (occurring at St. George's Hospital between October, 1874, and June, 1888), prepared by Mr. Dent, give a general mortality of 21 per cent. (*Med.-Chir. Trans.*, vol. lxxiii.)

One of us (J. H.), in the ten years from 1890 to 1900, at the London Hospital, performed 94 major amputations with eleven deaths, i.e. nearly 12 per cent. All amputations below the wrist and tarsal joints are excluded from this list, which is analysed in section 4 (page 486).

These statistics are of little comparative value, as it is impossible really to compare them. One surgeon includes minor operations, another excludes them. One will have dealt with many severe traumatic cases in which a high mortality is inevitable, another will not have met with any such cases.

2. **Influence of Age and Sex.**—Age has an important influence on the results of amputation. In the very young—those under the age of five years—it is not well borne, the mortality often being as high as between the ages of thirty-five and fifty. The mortality is lowest between the ages of five and fifteen. After fifteen the death-rate begins steadily to increase, although during the whole period of

twenty to forty the variation is not very great. From fifty to sixty-five the mortality rapidly increases.

Ashhurst gives the following conclusions from an extensive collection of statistics :—(1) In persons under twenty years old the operation is a comparatively safe one, but in patients from twenty to forty it is nearly *twice*, and in those over forty not far from *three times*, as apt to be followed by death as during the earlier period. (2) In persons over thirty years of age amputation is almost twice as fatal as in those who are younger.

It must be noted that the great mass of Ashhurst's statistics belong to the period before antiseptics. Mr. Dent's statistics give the following results :—

Age.	*Mortality.*
Under 5	12·5 per cent.
5 to 10	3·3 ,,
10 to 20	16·1 ,,
20 to 40	14·4 ,,
40 to 60	32·8 ,,
Over 60	70 ,,

Statistics show that the mortality of amputation is a little lower in women than in men. It must be remembered, however, that the cases of amputation in men are much more numerous, and include a larger proportion of operations for injury.

3. **Influence of the Cause of the Amputation.**—Amputations performed for disease are much less fatal to life than those performed for injury.

The records of the London Hospital for four years show the mortality after amputation of the leg or foot for injury to have been 12 per cent., and for disease to have been 4 per cent.

Mr. Page's statistics, dealing with 484 like cases, give a mortality in cases of injury of 12·3 per cent., and in disease of 4·9 per cent. Mr. Dent's series of cases shows a mortality of 15·2 per cent. in amputations for disease, and of 36·6 in amputations for injury. Primary amputations for injury are less fatal than secondary amputations for injury.

4. **Influence of the Site of the Amputation.**—Amputations in the upper limb are less fatal than those in corresponding parts of the lower limb, and in either limb the rate of mortality increases the nearer the amputation is to the trunk.

The following table is founded on the statistics collected by Ashhurst and others, and upon the results of amputation as shown in the records of the London Hospital. The figures are comparative

only. The unit or standard is the mortality after amputation of the fingers or thumb, and is here expressed by the figure 1. For example, the mortality after amputations of the arm is nine times greater than that following amputation of the fingers (the standard), while that attending disarticulations at the knee is sixteen times higher than the death-rate of the standard amputation.

Fingers or thumb	1	Toes	2
Partial amputation of hand ...	2	Partial amputation of foot... ...	7
Amputation at wrist-joint	4	Amputation at ankle-joint	5
,, of forearm	6	,, of leg	11
,, at elbow-joint	7	,, at knee-joint	16
,, of arm	9	,, of thigh	21
,, at shoulder-joint ...	12	,, at hip	24

The following personal statistics may be of interest. They are based on 94 major amputations performed at the London Hospital in the years 1890–1900 by one of us (J. H.) :—

Amputation at hip-joint	3 cases	... 2 deaths	(66 per cent.).
Amputation through the thigh as low as the knee	32 ,,	... 3 ,,	(9 per cent.).
Amputation through the leg or tarsus	38 ,,	... 3 ,,	(8 per cent.).
Amputation at shoulder-joint ...	6 ,,	... 2 ,,	(33 per cent.).
Amputation through the arm as low as the elbow	5 ,,	... 1 ,,	(20 per cent.).
Amputation through the forearm or wrist	10 ,,	... 0 ,,	

CHAPTER II

AMPUTATIONS OF THE FINGERS AND THUMB

GENERAL CONSIDERATIONS

Anatomical Points.—The skin on the palmar aspect of the fingers and the thumb is thick, dense, stiff, and adherent. There is very little subcutaneous tissue. The palmar integument is remarkably sensitive, especially that covering the pulp of the digits. The skin on the dorsum, on the contrary, is thin and loose, and beneath it is a stratum of lax connective tissue. Its sensibility is comparatively dull.

The position of the phalangeal joints must be clearly defined. It is to be borne in mind that the "knuckle" at both the metacarpo-phalangeal and interphalangeal joints is formed by the head of the proximal bone, and that the articular line is therefore beyond or below the knuckle. Of the transverse folds across the fronts of the fingers, produced by the joints, the highest is single for the index and little finger, and double for the other two. It is placed nearly three-quarters of an inch below the corresponding joint (Fig. 358). The middle folds are double for all the fingers, and are exactly opposite the first inter-phalangeal joints. The lowest creases are single, and are placed a little above the corresponding joints (from 1 to 2 mm.). There are two single creases on the thumb corresponding to the two joints, the higher crossing the metacarpo-phalangeal articulation obliquely. The free edge of the web of the fingers as measured from the palmar surface is about three-quarters of an inch from the metacarpo-phalangeal joints (Fig. 358).

All the joints are supported by two lateral ligaments and a glenoid ligament. The former are nearer to the palmar than the dorsal aspect; the latter exists as a firm fibro-cartilaginous plate, which is attached mainly to the base of the distal bone. In the metacarpo-phalangeal joint of the thumb two sesamoid bones replace this ligamentous palmar plate.

A single epiphysis exists for each metacarpal bone and phalanx. It forms the head of the four inner metacarpal bones and the base

of the metacarpal of the thumb and of the phalanges (Fig. 359). It joins the shaft at the age of twenty.

The fibrous sheaths for the flexor tendons extend from the metacarpo-phalangeal joints to the upper ends of the third phalanges. The pulp of the third phalanx, therefore, rests practically upon the periosteum. Opposite the finger-joints the sheaths are lax and thin. In the rest of their course they are dense and rigid, and when cut

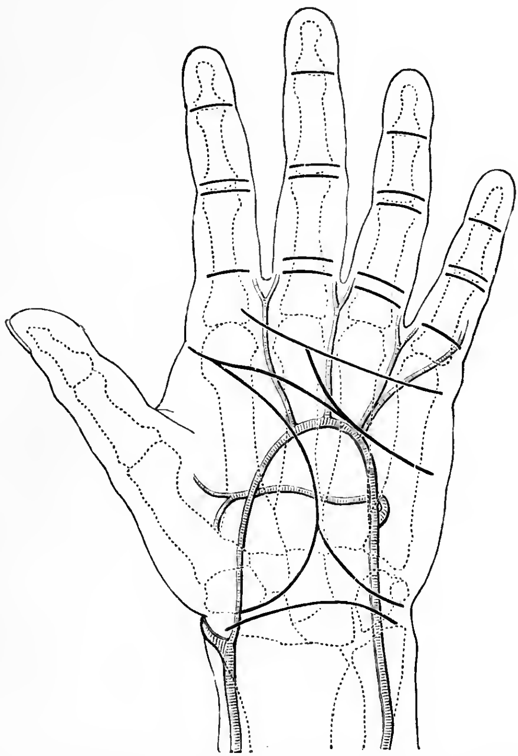

FIG. 358.—SURFACE MARKINGS ON THE PALM OF THE HAND. (The thick black lines represent the chief creases of the skin.)

across remain, in virtue of this rigidity, wide open, and form an open channel which leads into the palm of the hand (Fig. 360).

There are two synovial sacs beneath the annular ligament for the flexor tendons, one for the flexor of the thumb, the other for the two flexors of the fingers. The former extends up into the forearm for about $1\frac{1}{4}$ inches above the annular ligament, and follows the tendon to its insertion. The latter rises about $1\frac{1}{2}$ inches above the annular

band, and ends in diverticula for the four fingers. The process for the little finger usually extends to the insertion of the flexor profundus tendon in the last phalanx. The remaining three diverticula end about the middle of the corresponding metacarpal bones. The synovial sheaths for the digital parts of the tendons to the index, middle, and ring fingers end above about the neck of the metacarpal bones, and are thus separated by about half an inch from the great synovial sac beneath the annular ligament.

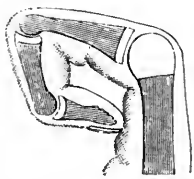

FIG. 359. — A FINGER FLEXED TO SHOW THE JOINT LINES AND THE EPIPHYSES.

Thus there is an open channel from the ends of the thumb and little finger to a point in the forearm about an inch and a half above the annular ligament. Therefore suppuration in the thumb and little finger is apt to be followed by abscess in the forearm.

The digital arteries are about the size of the posterior auricular, and run much nearer to the palmar than the dorsal surface.

The dorsal digital arteries of the thumb are of good size, but on the fingers they appear as quite insignificant vessels which can hardly be traced beyond the first phalanx.

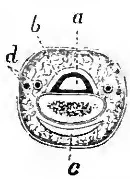

FIG. 360.—HORIZONTAL SECTION THROUGH THE MIDDLE OF THE SECOND PHALANX. (*Tillaux.*)

a, Flexor tendon; *b*, Fibrous sheath of tendon; *c*, Extensor tendon; *d*, Digital artery and nerve.

Parts removed.—Amputations of the fingers are often of necessity imperfect operations, and in some traumatic cases represent little more than a trimming of mangled parts.

In performing these operations every care should be taken to remove as little of the digit, and especially of the thumb and index, as possible. The shortest and most ungainly-looking stump of the thumb or of the forefinger may prove to be of the greatest value. A French surgeon has well said, "Le pouce représente à lui seul l'un des mors de la pince que forme la main."

If the thumb, or a portion of it, be left, it is important that it should have something with which to come into apposition; and in fulfilling this need the slightest stump of the forefinger is of considerable service. The little and ring fingers are of less importance, provided that the other digits remain; but in cases where the three or the two outer fingers have been removed, the little finger or the ring finger has been capable, in conjunction with the thumb, of performing most valuable and complex functions.

A hand with nothing left but the stumps of a thumb and of a little finger is more useful than the most elaborate artificial limb. Dr. Gregory (*Trans. Amer. Surg. Assoc.*, vol. ii., page 232) mentions the case of a lad who could hold a pen with a hand of which nothing had been saved but a small part of the thumb and the metacarpus and carpus.

The bone should always be divided as low down as possible. If only the base of the terminal phalanx can be saved, it will secure for the finger the attachment of the flexor profundus tendon. Amputation of the second phalanx should be performed through the bone whenever possible. If the upper half, or even the upper third, of the phalanx be left, some portion of the insertion of the flexor sublimis will be saved.

It is sometimes said that a stump formed of the whole or part of the first phalanx alone will be immobile and useless. With regard to the index and little fingers this is certainly not true, and even in the case of the middle and ring fingers the first phalanx alone will, as a rule, provide a useful and mobile stump. Of this fact we have seen many examples.

The Shaping of the Flaps.—As the bones of the finger are comparatively large in relation to the surrounding soft parts, the flaps must be cut comparatively long. Thus a single palmar flap should be equal to one diameter and a half of the digit. If unequal dorsal and palmar flaps are cut, the palmar flap should be longer than the diameter of the digit, while the dorsal flap should be about the third of the palmar. Farabeuf gives these measurements : If the breadth of the finger be 16 mm., a single palmar flap should be 24 mm. in length. If unequal flaps be made, the palmar should measure 18 mm., and the dorsal 6 mm.

Flaps should be so cut that the cicatrix is removed from pressure. The scar therefore should not be on the extremity of the stump nor upon its palmar aspect. In other words, the scar is most conveniently placed when placed upon the dorsum.

For this reason a single palmar flap or a predominating palmar flap (when two are cut) represents the best method in amputation through the fingers. The stump which results is covered with firm and vascular skin, well able to withstand pressure, and is endued with the remarkable sensibility of the part. A dorsal flap involves a covering for the stump which is thin, ill supplied with blood, little able to withstand pressure, and of slight sensibility. The oval method provides a stump with the good qualities furnished by the palmar flap.

The Closing of the Fibrous Sheaths.—The fibrous sheaths for the flexor tendons, when cut across, as in these operations, form rigid tubes along which pus, if suppuration should ensue, may pass and enter the palm of the hand. The flexor tendons retract after division, but the sheaths do not, so there is provided in the depths of the stump a natural drainage-tube, the remote end of which leads into the palm ; if no suppuration occurs, this hidden channel will produce no evil. It is soon occluded and unable to be harmful. If the stump, however, does suppurate, as may occur after crushes of the fingers, the pus can find its way with great readiness into the rigid patent fibrous tube, and then ensues deep-seated suppuration in the stump and in the palm.

To avoid this serious hindrance to healing, the fibrous sheath should be closed when possible after all amputations of the fingers and thumb in which there is any doubt as to the securing of a perfect aseptic condition. Over the terminal phalanx, and over the joint between the middle and the terminal phalanges, there is no fibrous sheath. In front of the metacarpo-phalangeal joint it is scarcely evident. Over the first and second (proximal and middle) phalanges, and in front of the joint between these bones, the fibrous sheath is well marked, and appears as a rigid tube when cut across.

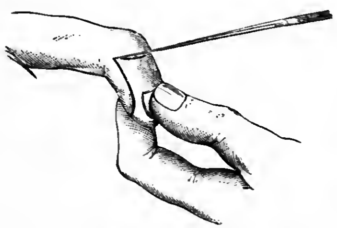

FIG. 361.—MODE OF HOLDING THE FINGER DURING DISARTICULATION OF THE LAST PHALANX.

As the sheath crosses the metacarpo-phalangeal and first inter-phalangeal joints, it is adherent to the glenoid ligament, and is easily closed by two fine catgut sutures passed vertically, i.e. from the dorsal to the palmar wall.

Opposite the shafts of the first and second phalanges, however, there is much difficulty in effecting this closure, since the sheath is united to the periosteum, and that membrane is very thin. In these situations the periosteum should be stripped up a little from the palmar aspect of the bone, and the orifice of the tube secured by two fine sutures passed either vertically or transversely, as may appear the more convenient. This stripping off of periosteum should be effected before the bone is divided.

Instruments required.—Narrow, slender, and strong scalpels, the blades of which should be equal in length to about one diameter and a half of the digit to be removed. (A fine scalpel with a cutting

edge one inch in length will serve admirably for most amputations of the fingers. The "finger knife" of the instrument-makers is an absurd instrument. Its blade is, according to one catalogue, nearly three inches in length. Such large knives were at one time employed, and in Fergusson's figure of an amputation through the second phalanx the knife depicted has a blade which must have been some four inches long.) A fine key-hole saw or very small Butcher's saw. Bone forceps. Dissecting and artery forceps. Sterilised strips of bandage or gauze to hold aside the fingers. Scissors, needles, etc.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of pronation while dorsal incisions and flaps are being made, and in supination during the fashioning of palmar flaps.

In the oval operation the limb may be kept pronated throughout, and disarticulation is in any case conveniently effected in that position.

The surgeon holds with his left hand, placed in the supine position, the finger to be removed (Fig. 361). An assistant is placed opposite to the surgeon. He holds the patient's hand in the required position, and keeps the sound digits out of the way.

AMPUTATION OR DISARTICULATION OF THE PHALANGES OF THE FINGERS

These operations include amputations through the proximal, middle, or terminal phalanges, and disarticulations at the first or second interphalangeal joints. An amputation *through* the terminal phalanx can scarcely claim to be a defined operation.

Four methods will be described :—

1. By single palmar flap.
2. By unequal dorsal and palmar flaps.
3. By single external flap.
4. By lateral flaps.

1. **By Single Palmar Flap.**—Illustrated by the removal of the last phalanx at the joint.

Hold the digit between the left thumb and forefinger (the thumb upon the pulp of the digit, the forefinger on the nail). Ascertain the position of the joint. Commence the incision upon one side of the finger opposite to the joint-line and midway between the dorsal and palmar aspects of the digit. Mark out the palmar flap by an incision which involves the skin only. This flap will include the greater part of the pulp of the finger (Fig. 362). Now carry the

incision to the bone throughout, and dissect up the flap so freed, including in it everything down to the bone.

Let the patient's finger be then flexed, and make the dorsal incision. This incision is carried transversely across the finger at the level of the base of the distal phalanx. Retract the soft parts a little and open the joint.

Divide the lateral ligaments. Nothing now connects the phalanx with the rest of the finger but the flexor profundus tendon and the glenoid ligament. Put the terminal phalanx in the position of extreme extension, and divide these two structures by cutting from below up against the base of that phalanx. No vessels require to be secured, and the tendon sheath is not opened.

2. **By Unequal Dorsal and Palmar Flaps.**—Illustrated by disarticulation at the first interphalangeal joint.

The palmar flap should exceed a little in length the diameter of the digit at the line of the joint. The dorsal flap is one-third the length of the palmar flap. (*See* Fig. 362, c.)

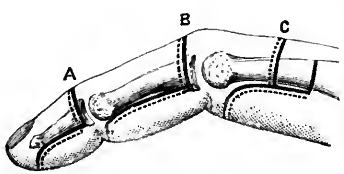

FIG. 362.—A and B, Disarticulation by large palmar flap; C, Amputation by unequal dorso-palmar flaps.

Ascertain the line of the articulation. Hold the finger in the position of pronation, and mark out the flaps by skin incisions. The flaps should be squarely cut. The lateral incisions should be placed midway between the dorsal and palmar surfaces, and should be commenced just above the joint-line. Carry the lateral cuts to the bone. Flex the finger strongly and carry the dorsal incision to the bone. Dissect up the dorsal flap, including in it all the soft parts to the bone. Open the joint from the dorsal aspect. Dissect up the palmar flap, dividing the flexor tendon at the end of the flap while the finger is in the extended position. This flap also includes all the soft parts to the bone. When the joint is reached, divide the lateral ligaments, separate the glenoid ligament from the base of the second phalanx, and the disarticulation is completed. The tendon sheath may be closed (page 492).

If an attempt is to be made to secure the flexor tendons a point of attachment to the bone, the divided extremity of each (or the free end of the flexor profundus tendon only) is attached to the remains of the fibrous sheath and to the glenoid ligament (which is left in the stump). The tendons are thus made to occupy the fibrous sheath, which is readily closed around them.

No vessels will probably require ligature. The dorsal arteries are cut at the end of the palmar flap.

3. **By Single External Flap.**—Illustrated by disarticulation at the first interphalangeal joint.

The flaps are fashioned as shown in Fig. 363, A. The two longitudinal incisions are in the centre of the dorsal and palmar surfaces respectively, and both commence just above the level of the joint.

The outer transverse incision—marking the extremity of the external flap—is opposite the centre of the second phalanx. The inner transverse incision is opposite the joint.

The external flap, having been marked out, is dissected up. It contains all the soft parts down to the tendons.

The finger having been fully flexed, the joint is opened from the dorsum by cutting through the extensor expansion.

The lateral ligaments of the joint are now cut.

The finger is then placed in the position of extension, and the flexor tendons and the attachment of the glenoid ligament are divided from below up against the base of the second phalanx.

The tendons and the tendon-sheath may be dealt with as in the previous operation.

The digital vessels are divided in the transverse incisions, but will probably not require ligatures.

4. **By Lateral Flaps.**—Illustrated by amputation through the second phalanx.

The external and internal flaps are of equal size, and do not equal in length the diameter of the finger (Fig. 363, B). The dorsal and palmar incisions are median. The flaps are squarely cut, and contain all the soft parts down to the tendons. The flexor profundus tendons and the expansions from the flexor sublimis and extensor tendons are divided circularly at the saw-line. The bone is divided with a fine saw. (*See* Comments, page 496, par. 5.)

The digital arteries are cut at the extremities of the flaps.

Appreciation of the above Operations.—Of these four procedures the first-named two are the best. The importance of the palmar flap has already been dwelt upon (page 491).

The third method—that by an external flap—answers well when the tissues upon the palmar and inner sides of the finger are damaged. It is peculiarly well adapted for the index finger. A precisely similar single flap may be cut from the inner side of the finger, but in the case of the index the cicatrix would be very inconveniently placed. The internal flap method is well suited to some amputations of the inner fingers.

The amputation by the lateral method produces well-nourished flaps and a shapely stump, but the cicatrix is inconveniently placed; and if the healing be imperfect, there is a disposition for the bone to project between the flaps.

Equal palmar and dorsal flaps produce a stump with the cicatrix at its extremity.

The oval method is not well adapted for these amputations. If it is applied to effect a disarticulation, the dorsal incision should commence just above the joint, and the circular incision be about the centre of the phalanx below (Fig. 363, C). The resulting stump is clumsy, and the cicatrix is ill placed.

General Comment upon the above Operations.—1. A longitudinal cut made in the centre of the lateral surface of the finger—i.e. midway between the dorsum and the palmar aspect—will not wound the digital artery, which will be found intact in the palmar flap.

2. In no operations upon the fingers is it well to cut the flaps by transfixion. In cutting a palmar flap by this means there is danger of slitting up the digital arteries. The flap, moreover, is apt to be pointed and scanty, and to contain fragments of tendon.

3. In disarticulations a very slight dorsal flap is a decided advantage, and allows a better covering to be provided for the head of the bone.

4. Disarticulation may be effected in finger amputations by cutting from above downwards. The joint is exposed from the dorsum, the finger being fully flexed; the lateral ligaments are divided; the knife is then passed behind the base of the distal bone, and is made to cut its way outwards in the direction of the palmar surface.

This method is not so precise as that indicated in the forma account of the operation. The base of the distal phalanx often offers an obstacle to the passage of the knife; the glenoid ligament —which should be left in the stump—is apt to be cut away, and damage may be inflicted upon the tissues of the palmar flap.

5. A very fine saw is much to be preferred to the bone-forceps for dividing the phalanx. The forceps are apt to splinter the bone, especially in the fingers of well-developed adults and in old persons (page 483).

DISARTICULATION OF FINGERS AT THE METACARPO-PHALANGEAL JOINTS

These operations are performed with great frequency, and represent the most common amputations of the fingers.

It is well that the cicatrix should come upon the dorsum of the hand, and that the operation should be so carried out as to involve the least possible interference with the palm.

The following disarticulations will be described:—

1. By the oval method.
2. By lateral flaps.
3. Operations for the forefinger.
4. Operations for the little finger.

1. **By the Oval or Racket Method.**—The method here described corresponds to the French *incision en croupière,* and does not exactly accord with either the orthodox racket incision or the unmodified oval operation.

The dorsal incision is commenced just above the head of the metacarpal bone (i.e. opposite to its neck), and is carried down in the median line of the finger until it has passed the base of the phalanx.

The cut now divides, and its limbs sweep obliquely across each side of the root of the finger. They are joined on the palmar aspect by a transverse incision, which exactly follows the crease between the finger and the palm, and is therefore level with the free margin of the web (Fig. 363, F).

The surgeon, having made out the position of the joint, holds the finger in the prone position in his left hand. An assistant steadies the hand and keeps the other fingers out of the way.

Throughout the whole operation the limb is kept in the prone position. The knife is entered upon the dorsum, and is carried first across one side of the root of the finger and then across the other side. The incision is completed by the transverse palmar cut. Three separate cuts with the knife are therefore required.

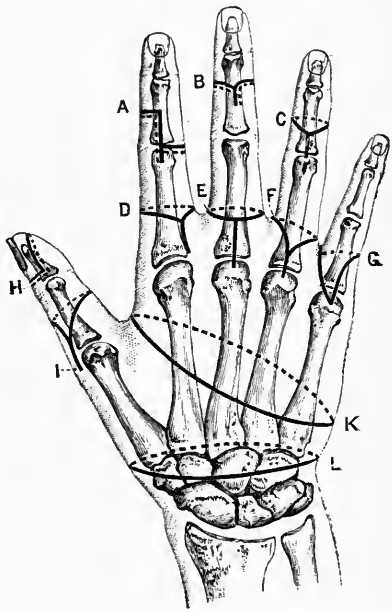

FIG. 363.—A, Disarticulation by single external flap; B, Amputation by lateral flaps; C, Disarticulation by oval or racket incision; D, Modified racket incision for index finger; E, Circular method, with vertical dorsal cut; F, Incision *en croupière*; G, Interno-palmar flap method for little finger; H, Disarticulation by single palmar flap; I, Disarticulation by racket incision; K, Amputation of fingers with their metacarpal bones; L, Circular disarticulation at the wrist.

There is no object in attempting to make the entire incision with one sweep of the scalpel. The incision should at first involve the skin only.

The finger is now extended to its utmost, and the palmar incision is carried to the bone, the flexor tendons being thus stretched and divided. The finger being then turned to one or other side, the lateral

incisions—on each aspect of the root of the finger—are carried to the bone. In this way the digital arteries are cleanly divided, and the expansions from the lumbricals and interossei are cut.

The assistant now takes the finger, while the surgeon dissects back the flaps, as far as the joint-line, with the aid of forceps.

The wrist and finger being fully extended, the operator once more takes hold of the digit and proceeds to open the joint from the palmar aspect. He cuts the glenoid ligament transversely against the base of the phalanx, divides the lateral ligaments, and finally completes the operation by cutting the extensor tendon. Disarticulation may be effected from the dorsum, but it renders the section of the glenoid ligament a little less easy.

The synovial sheath for the flexor tendons may be closed. The glenoid ligament remains in the stump. The two palmar digital arteries will require to be ligatured or twisted. The cicatrix is vertical —i.e. in the long axis of the limb.

2. **By Lateral Flaps.**—The method here described is that often known as Lisfranc's operation.

The flaps are of equal size and are a little rounded. The base of each corresponds to the joint-line, the free extremity of each to the level of the web. The median dorsal cut commences just above the metacarpo-phalangeal joint. The palmar median incision extends into the palm up to the level of that joint (Fig. 364, B).

The *modus operandi* is as follows :—

The surgeon marks out both the flaps by skin incisions. He then dissects up one of the flaps (that to his right) until the joint is reached. This flap includes all the soft parts down to the bone, and the digital artery is divided at its free extremity.

He then opens the joint by cutting the exposed lateral ligament, viz. that to his (the surgeon's) right.

Holding the knife vertically, with the blade directed upwards, the operator passes it across the joint, cuts the opposite lateral ligament, and then fashions the other lateral flap (that to the surgeon's left) by cutting from within outwards.

All the tendons are divided at the joint-level, and are severed as the knife is passed transversely across the articulation.

The digital vessels are cut at the free end of each flap.

3. **Modified Operations for the Forefinger.**—In order that the cicatrix may not be exposed to pressure when the thumb is opposed to the stump, or when anything is being held in the hand, the following modified procedures may be carried out :—

(*a*) By the racket incision, with the vertical cut placed upon the

side of the index nearest to the middle finger, and with the incision carried a little farther on the radial than on the ulnar side of the digit. In the latter situation it corresponds to the web (Fig. 363, D).

(*b*) By unequal lateral flaps, the external flap being the larger.

(*c*) By the externo-palmar flap of Farabeuf. The incision commences at the joint-line, just to the radial side of the extensor tendon. It is carried down along the outer side of the dorsum nearly as far as the centre of the shaft of the phalanx. It is then made to sweep across the palmar aspect of the finger to the web. From the web it passes by the shortest route to the point at which the incision commenced (Fig. 364, A).

The large flap is dissected up, carrying with it all the soft parts down to the bone. The tendons are divided and disarticulation is effected in the usual way.

4. **Modified Operations for the Little Finger.**—These have for their object the removal of the cicatrix from an exposed position.

(*a*) By a racket incision, with the vertical cut placed upon the side of the digit nearest to the ring-finger, and with the incision carried a little farther on the ulnar than on the radial side of the finger.

(*b*) By unequal lateral flaps, the internal being the larger.

(*c*) By the interno-palmar flap of Farabeuf (Fig. 363, G). It corresponds to the flap already described as employed for the index finger, with the necessary difference that the position of the incisions is transposed.

Comment on the above Operations.—In all these disarticulations the head of the metacarpal bone should be spared whenever possible.

It is unreasonable to sacrifice it simply on the ground that—in a particular case—the covering of soft parts is scanty.

It is still more unreasonable to sacrifice it on the ground that its removal improves the aspect of the mutilated hand. The appearance of the part may certainly be improved at the moment of the operation, but in the course of time the unnaturally narrow extremity does not compare favourably with the hand marked by an unduly wide gap between the fingers.

The head of the bone, if left, appears to waste. The soft parts about it certainly waste ; and if the hand be inspected six months after the disarticulation, it will seldom be evident that the removal of the head of the bone would have led to an improvement in the appearance of the part.

The excision of the head weakens the hand greatly, an effect due probably to a severing of the connections of the transverse ligament.

Its removal involves, moreover, an opening up of the tissues of the palm.

Of the two operations first described, the better is undoubtedly that by the racket incision. The cicatrix in this operation is well placed, and the tissues of the palm are not disturbed. The edges of the wound come fairly well together, but a little pocket is apt to be left in the palmar tissues just in front of the head of the metacarpal bone, in which pouch effusions may collect.

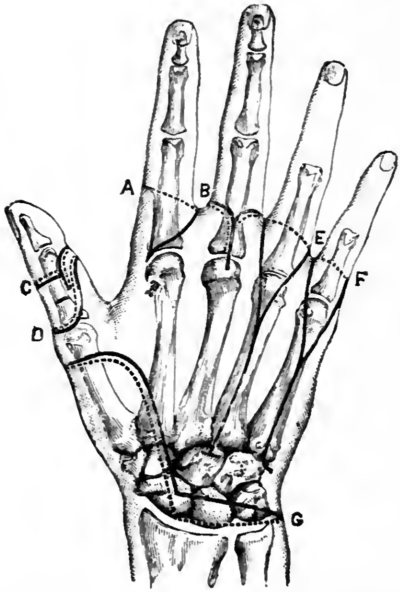

FIG. 364.—A, Disarticulation by special externo-palmar flap; B, Disarticulation by lateral flaps; C, Amputation by unequal dorso-palmar flap; D, Disarticulation by oblique palmar flap; E, Disarticulation of the ring finger, with its metacarpal bone, by racket incision; F, Same operation upon the little finger; G, Dubrueil's disarticulation at the wrist.

The operation by lateral flaps has the advantages of affording a good covering to the bone, a wound that can be neatly approximated, without allowing any "pocket" to be formed, and consequently good drainage. It has the drawback, however, that the cicatrix is carried into the palm

The method by means of a circular incision at the level of the web with a median dorsal cut (Fig. 363, E), affords a most excellent covering to the bone, but it provides a somewhat clumsy stump.

The various operations for the index and little fingers call for no especial comment. Farabeuf's methods by interno-palmar or externo-palmar flaps are probably the best, while the method of unequal lateral flaps is the least to be advised.

AMPUTATIONS AND DISARTICULATIONS OF THE THUMB

In performing an operation through the first or the second phalanx, or in disarticulating at the interphalangeal joint, one or other of the methods already described may be employed (Fig. 363, H, and Fig. 364, C).

The comments made on these operations apply equally when they concern the thumb. In any amputation below the interpha-

langeal joint the sheath for the flexor tendon should be closed. There are four digital arteries to the thumb, and two at least of these will probably need to be secured.

Disarticulation at the Metacarpo-phalangeal Joint.—It may be remembered that the extensor primi internodii pollicis, the abductor and the adductor pollicis, and the flexor brevis pollicis, all find insertion into the base of the first phalanx.

The methods described in the previous chapter apply in general terms to this disarticulation. The two most suitable operations are the following :—

1. *By the Racket Incision.*—The incision commences upon the dorsum, opposite the neck of the metacarpal bone, and is continued down along the line of the extensor tendon until the base of the first phalanx is passed. Here the incision divides to form the oval, the palmar cut crossing the thumb transversely about opposite to the centre of the shaft of the phalanx (Fig. 363, I).

The steps of the operation have been already described (page 497). Disarticulation may be effected from the dorsum.

The two extensor tendons are divided opposite to the joint-line. The flexor longus pollicis tendon may be severed opposite to the palmar incision, and the extremity of the tendon may be attached to the sesamoid bones. The latter structures should be carefully detached from the base of the phalanx, and are left in the stump. The sheath for the long flexor tendon should be closed. Two or more digital vessels will probably require ligatures.

2. *By Oblique Palmar Flap.*—This is Farabeuf's method. It is most excellent in cases where the tissues permit of so large a flap being cut. The dorsal incision is **U**-shaped, the concavity being towards the nail, and the bend of the **U** opposite to the joint-line. The palmar incision is **U**-shaped, the convexity being towards the nail, and the bend reaching nearly to the interdigital fold in the skin. The lines of the cut follow the lateral borders of the thumb (Fig. 364, D). The flap is dissected up in the usual way. The extensor tendons are divided opposite to the joint, and the long flexor about the middle of the phalanx. The operation is finished in the manner already described.

AMPUTATIONS OF THE FINGERS AND THUMB, TOGETHER WITH PORTIONS OF THE METACARPUS

These operations include the partial or complete removal or one or more metacarpal bones, together with the corresponding digit or digits. They are seldom performed in their entirety in actual

practice. There are but few conditions in either injury or disease which could render them possible. The least infrequent of these operations concern the amputation of the thumb with its metacarpal bone, and the removal of crushed fingers together with such part of the metacarpus as is hopelessly damaged.

As dead-house operations, the procedures here described form very admirable exercises.

In this part of the hand the rule still holds good that every portion of tissue should be spared whenever possible.

Anatomical Points.—The main dangers of these operations consist in possible damage inflicted upon the tissues of the palm, in wounding the deep palmar arch or the termination of the radial artery, and in opening up the general synovial sac of the carpus, or the scarcely less important synovial sac about the flexor tendons beneath the annular ligament.

The surface markings on the palm of the hand should be called to mind, together with their relations to the metacarpal bones and the palmar arches (Fig. 358). The great crease produced by the apposition of the thumb is very noteworthy. The lowest transverse crease on the palm crosses the necks of the metacarpal bones, and indicates pretty nearly the upper limits of the synovial sheaths for the flexor tendons of the three outer fingers. A little way below this fold the palmar fascia breaks up into its four slips, and midway between the fold and the webs of the fingers lie the metacarpo-phalangeal joints.

The aspect of the carpo-metacarpal line of joints—from the dorsum—is to be observed; the saddle-shaped surface of the base of the first metacarpal bone as it articulates with the trapezium; the **V**-shaped articular line between the metacarpal of the index and the trapezoid; the remarkable projection (styloid process) from the base of the third metacarpal bone at its dorsal and radial aspect, and the comparative simplicity of the joints connecting the two inner bones with the unciform.

The base of the metacarpal bone of the thumb is formed by an epiphysis which joins the shaft about the age of twenty.

A separate and isolated synovial cavity separates both the first metacarpal and the fifth from their respective carpal bones. The remaining metacarpals are separated from the carpus by the common synovial sac of the hand. The joint between the thumb and the trapezium is provided with a distinct capsule.

The bases of the four inner metacarpals are united by transverse dorsal, palmar, and interosseous ligaments. A strong and special interosseous band passes between the os magnum and os unciform and

the bases of the third and fourth metacarpal bones. To the base of the first metacarpal is attached the extensor ossis metacarpi pollicis; to the base of the second, the extensor carpi radialis longior and the flexor carpi radialis; to the base of the third, the extensor carpi radialis brevior; and to the base of the fifth bone, the extensor carpi ulnaris and some fibres of the flexor carpi ulnaris. To the shafts of all the bones some portions of the interossei muscles are attached, and into the shafts of the metacarpals of the thumb and little finger are inserted in addition the corresponding opponens muscle.

The joint of the thumb is easily defined on movement. In removing the metacarpal bone of that digit, the details of the *tabatière anatomique* should be called to mind. The space so named is bounded by the extensor secundi internodii pollicis on the one side and the extensores ossis metacarpi and primi internodii on the other.

In its floor are the scaphoid, the trapezium, and the carpo-metacarpal joint of the thumb. The extensor secundi tendon just crosses the apex of the first interosseous space. The radial artery runs over the floor of the *tabatière* and passes through the apex of the interspace to reach the palm. The position of the synovial sheaths of the flexor tendons has been already indicated (page 489). The deep palmar arch crosses the shafts of the second, third, and fourth metacarpal bones close to their bases (Fig. 358).

Each digital artery bifurcates a little more than one quarter of an inch above the free edge of the web of the finger.

Instruments.—A stout narrow scalpel with a blade about $1\frac{1}{2}$ inches long will suffice for the oval methods, and a slender bistoury, with a cutting edge of some $2\frac{1}{2}$ to 3 inches, is required for transfixion operations. A fine keyhole-saw. Small retractors. Bone-forceps. A rugine, if the periosteum is to be preserved. Dissecting and artery-forceps. Scissors, needles, etc.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of pronation. The operator grasps the finger to be removed, keeping his hand supine. An assistant, placed opposite to the surgeon, holds the patient's hand in the required position, and keeps the sound digits out of the way.

The following procedures will be described:—

1. Partial amputations.
2. Disarticulation of a finger with its metacarpal bone.
3. Disarticulation of the thumb with its metacarpal bone.
4. Amputation of several fingers with their metacarpal bones.

1. **Partial Amputations.**—As much of the metacarpus should be preserved as is possible. In such partial operations the deep palmar arch is not exposed to the risk of being wounded : the attachments of certain tendons are preserved, the carpo-metacarpal synovial sacs are not opened up, and if the bone be divided beyond its centre the synovial sacs of the flexor tendons may escape the knife in the case of the three middle digits.

The racket method should be employed. The vertical incision follows the median dorsal line of the metacarpal, while the oval cut traverses the web and follows the transverse digito-palmar crease. The general features of the operation are the same as in the complete disarticulations (*vide infra*). The dorsal incision should be commenced a little way above the point at which it is intended to divide the bone. The bone should be severed with a saw whenever possible, the soft parts being protected by a director during the passage of the instrument. The shaft is apt to be much crushed if bone-forceps are employed. The second and fifth metacarpals should be divided obliquely, so that the end of the bone may not project unduly upon the margin of the hand.

2. **Disarticulation of a Finger with the corresponding Metacarpal Bone.**—The racket incision is conveniently employed. The operation may be illustrated upon the *ring finger* (Fig. 364, E). The joint-line having been made out, the *queue* of the racket is commenced just above the articulation, and is carried down along the dorsum of the metacarpal until the base of the knuckle is reached.

The incision here divides, and the oval wound, following the clefts between the fingers, crosses the web and terminates transversely at the digito-palmar crease in the skin. The incision involves at first the skin only, the surgeon holding the finger and manipulating it as required with his left hand.

An assistant now takes charge of the finger while the surgeon deepens the dorsal incision and divides the extensor tendons just beyond the base of the bone. The sides of the shaft of the metacarpal are now bared from one end to the other, the knife being kept very close to the bone. During this step the surgeon uses his left finger to assist in the separation of the interossei from the shaft, the assistant rotating the digit as required.

The knife is carried back between the bases of the metacarpal bones (on either side of the bone to be removed), so as to divide the interosseous ligaments ; the skin is at the same time retracted, so as to expose the part. To reach the articulation more conveniently,

a transverse cut may be made at the end of the vertical incision (Fig. 364, E).

The operator now carries the knife forward through the tissues of the web on either side of the finger, and, the digit being fully extended, the palmar incision is carried down to the flexor tendons. The assistant then holds the finger in the position of the extremest extension, while the surgeon lays bare the under-surface of the flexor tendons, which he ultimately divides opposite the neck of the shaft. While the finger is still extended to the utmost, the operator exposes the palmar surface of the bone as well as is possible and as far back as is possible. The ligaments of the joint having been divided, the finger is turned back upon the dorsum of the hand, and the last structures divided are such resisting palmar structures as still remain, together with the tendon of the extensor carpi radialis brevior.

The digital arteries are divided in the tissues of the web.

The synovial sheath of the flexor tendons may be closed with fine catgut sutures, if considered desirable.

In the case of the *index finger* the vertical incision should be carried along the dorsum of the bone rather than along its radial side, as sometimes advised. A transverse cut should be made over the trapezoid at the end of this incision.

In removing the *little finger* with its metacarpal bone, the dorsal incision should be placed rather towards the inner side of the shaft of the bone, and from its extremity a short transverse cut may be made towards the ulnar margin of the hand (Fig. 364, F).

In clearing the bone it is convenient to have the patient's elbow held upon the table by an assistant, who at the same time flexes the forearm until it is nearly vertical, and well abducts the finger to be removed.

The metacarpal is removed laterally, and is not turned up on the dorsum of the hand. During its removal it is made to assume the position of the extremest abduction.

The operation by lateral internal flap cut by transfixion is to be condemned. It has no advantages, and involves a scar upon both the dorsal and palmar aspects of the hand.

3. **Disarticulation of the Thumb, together with its Metacarpal Bone.**—In this operation especial care must be taken not to wound the radial artery as it passes close to the base of the metacarpal bone to reach the palm, and not to open the joint between the metacarpal of the index and the trapezoid.

One of the two following methods may be employed :—

(1) *The Racket Method.*—The hand is to be held in the mid-position

between pronation and supination. The wrist is steadied by an assistant while the surgeon holds the thumb.

The dorsal incision commences in the *tabatière*, just above the carpo-metacarpal joint, and on the tendon of the extensor primi internodii pollicis. It runs along the dorsum of the thumb, keeping nearer to the external than the internal border of the metacarpal bone. The oval encircles the head of that bone and crosses the palmar aspect of the digit on a level with the free edge of the web (Fig. 365). The incision at first involves the skin only, and the operator himself holds and manipulates the member while the racket is being made. An assistant now takes the thumb, and the surgeon proceeds to deepen the dorsal incision to the bone, cutting the extensores primi and secundi as high up as possible.

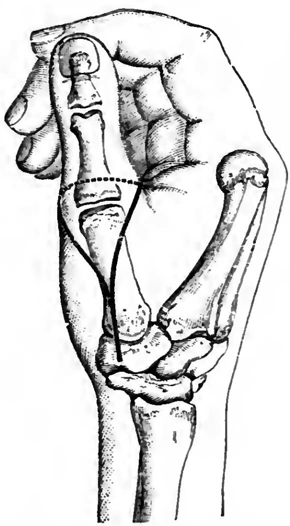

FIG. 365.—DISARTICULATION OF THE THUMB WITH ITS METACARPAL BONE BY A RACKET INCISION.

The dorsal surface of the bone and each side of it are then bared of soft parts as far as can be effected from the dorsum.

The knife must throughout be kept close to the bone.

The thumb is now forcibly abducted. The palmar incision is deepened. The muscles attached to the base of the first phalanx are divided close to the sesamoid bones.

The thumb being turned and rotated from side to side by the assistant as required, the palmar surface of the metacarpal is cleared, the knife being kept close to the bone. The long flexor tendon may be divided about the middle of the metacarpal bone. The operator once more takes hold of the thumb, and wrenching it from side to side as needed, effects the disarticulation. Probably the last structure divided is the tendon of the extensor ossis metacarpi pollicis. The sheath of the flexor tendon may be closed.

The arteria princeps pollicis, or its two collateral branches, will be found divided on the palmar aspect of the wound, and will require a ligature. The vessel runs along the palmar side of the metacarpal bone, and bifurcates between the heads of the flexor brevis and under cover of the long flexor.

The two dorsal arteries of the thumb are small, and may not require to be secured.

(2) *By Palmar Flap.*—This operation may be rapidly performed, but it is decidedly inferior to the method just described. A considerable section of the muscular tissues is made; there is greater danger of wounding the radial in the palm and of opening a carpal joint. The flap is cut by transfixion, and the procedure is clumsy.

An assistant holds the finger while the surgeon abducts the thumb. The knife, introduced into the centre of the web, passes beneath the muscles of the thumb, and emerges at the base of the metacarpal bone. By cutting outwards a rounded flap is formed, comprising the whole of the tissues of the thenar eminence (Fig. 366, A). The extremities of this flap are now united by a straight dorsal cut, the thumb being still abducted, the remaining soft parts are divided, the joint opened on the inner side, and the disarticulation completed.

On the left hand the flap may be formed by introducing the knife at the base of the metacarpal bone and bringing it out at the centre of the web.

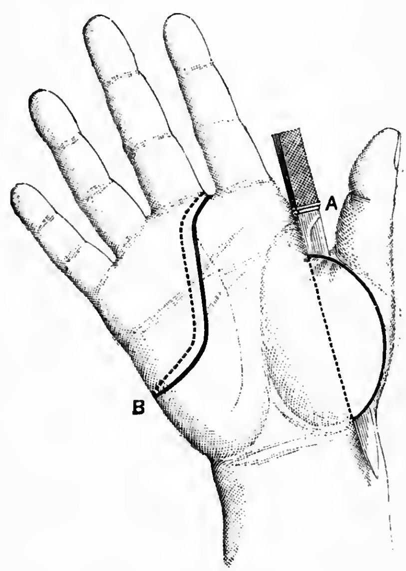

FIG. 366.—A, Disarticulation of the thumb with its metacarpal bone by palmar flap; B, Amputation of the three inner fingers with their metacarpal bones.

4. **Amputation of several Fingers, together with their Metacarpal Bones.**—These operations cannot be systematised, and the majority of the procedures which figure in French manuals must be regarded merely as ingenious dead-house operations.

These amputations concern for the most part cases of crush of the hand and of frost-bite, in which the least amount of tissue is sacrificed, and in which definite flaps can seldom be cut or definite incisions followed.

The following may be briefly cited as methods which are at least theoretically suitable.

(1) *Amputation of the Two Inner Fingers and their Metacarpal Bones.*—The racket method may be employed. The dorsal incision commences on the outer side of the base of the fifth metacarpal, and after following the fourth interosseous space for about one inch it divides, one limb severing the web between the middle and ring finger, and the other crossing the knuckle of the little finger on its inner side. The two extremities of this Y-shaped incision are joined by a transverse palmar cut following the palmo-digital creases.

(2) *Amputation of the Three Inner Fingers with their Metacarpal Bones.*—The knife follows the lines shown in Fig. 366, B. The incision commences a little way below the base of the fifth metacarpal, runs downwards and outwards across the palm below and parallel to the main transverse crease. It is then directed towards the head of the middle finger, and finally divides the web to the outer

side of that digit. A similar incision is made upon the dorsum, and in this way equal dorsal and palmar flaps are made.

(3) *Amputation of all the Fingers with their Metacarpal Bones.*—Here a short palmar flap may be made. The lines of the incisions are shown in Fig. 366, B. The dorsal wound is concave forwards, the palmar wound convex.

Some surgeons cut the palmar flap by transfixion.

In any of the operations named the metacarpal bones may be sawn through near their bases, or may be completely removed by disarticulation.

AFTER - TREATMENT OF AMPUTATION OF THE FINGERS AND THUMB

The wounds after these operations as a rule heal well.

As the skin of palmar flaps is usually thick and stiff, the sutures should be well applied, and should not be too soon removed. Silk-worm-gut sutures are well adapted for these operations. The hand should be kept elevated, and never allowed to hang down, and care must be taken that too tight bandages are not applied about the wrist. In the larger operations, especially where a palmar flap has been cut, the hand should be supported upon a splint in order to arrest the movements of the wrist. As a rule no drainage-tube is required ; but when the metacarpus is concerned, and when the tissues of the palm have been lacerated or opened up, a tube may with benefit be introduced and retained for some twenty-four or forty-eight hours. The partial operations following upon crushes of the hand must be treated upon the same principles as apply to complicated wounds.

CHAPTER III

AMPUTATIONS THROUGH WRIST AND FOREARM

I. DISARTICULATION AT THE WRIST

Opportunities for the performance of this operation are not common. In cases of injury the soft parts may be so extensively damaged as to involve amputation of the forearm ; or the lesion may be so limited as to make it possible to save the carpus or a part of the metacarpus, with possibly a finger.

In cases of disease of the carpal bones requiring amputation, the skin about the wrist is usually so involved and so penetrated by sinuses that the limb has to be removed higher up. As, moreover, the movements of pronation and supination have probably been lost during the progress of the disease, there is less reason for disarticulation in these cases.

The operation has been performed in instances in which excision of the wrist has failed.

Anatomical Points.—The styloid process of the radius lies more anteriorly than does the corresponding process of the ulna, and also descends nearly half an inch lower down the limb. Most of the tendons about the wrist can be made out through the skin. The palmaris longus tendon is nearly opposite to the centre of the wrist in front. A little to its outer side is the larger but less prominent tendon of the flexor carpi radialis. In the groove between these two tendons lies the median nerve. Of the tendons at the back of the wrist, the most conspicuous is that of the extensor secundi internodii pollicis. It leads up to a small bony elevation at the back of the radius, which serves to indicate the centre of the posterior surface of that bone, and also the position of the interval between the scaphoid and semilunar bones.

When the hand is supine, the styloid process of the ulna is exposed at the inner and posterior aspect of the wrist, to the inner side of the extensor carpi ulnaris. In pronation, however, the process is rendered indistinct, while the head projects prominently on the posterior part

of the wrist, and is found to lie between the tendons of the extensor carpi ulnaris and the extensor minimi digiti.

The tip of the styloid process of the ulna forms the best guide to the wrist-joint. A knife introduced below that point of bone will enter the articulation. A knife entered horizontally just below the tip of the radial styloid process will hit the scaphoid bone. A line drawn between the two styloid processes slopes downwards and outwards, and represents the extreme inferior limits of the radio-carpal joint, while it is at the same time nearly half an inch below the summit of the arch of that articulation.

Of the several folds in the skin on the front of the wrist, the lowest is the most distinct (Fig. 358). It is a little convex downwards, crosses the neck of the os magnum in the line of the third metacarpal bone, and is nearly three-quarters of an inch below the arch of the wrist-joint. It is about half an inch above the carpo-metacarpal joint-line, and indicates very fairly the upper border of the anterior annular ligament.

The skin on the dorsum of the wrist is thin, and the subcutaneous tissue is scanty and very lax. The integuments, as a consequence, retract very considerably when divided. Farabeuf states that 3 cm. should be allowed for this retraction, which he characterises as enormous.

The bony eminences formed by the tubercle of the scaphoid and the ridge of the trapezium on the one side, and the pisiform bone and the unciform process on the other, should be defined. The anterior annular ligament, which is about the size and shape of a postage-stamp, extends between them, and bridges over the hollow in which the main tendons run.

The position and extent of the synovial sheaths for the flexor tendons have been already alluded to (page 489).

Beneath the posterior annular ligament are six synovial tendon-sheaths. The sheaths for the extensors of the metacarpal bone and first phalanx of the thumb and for the radial extensors reach some three-quarters of an inch above the radial styloid process. The remaining sheaths extend only to the upper margin of the annular ligament.

The position of the palmar arches must be borne in mind. The deep branch of the ulnar artery arises immediately below the pisiform bone. The radial, to reach the back of the wrist, crosses the external lateral ligament of the wrist upon which it rests.

The wrist-joint has a separate synovial sac. The synovial sheath of the extensor minimi digiti sometimes communicates with the inferior

radio-ulnar joint. Of the ligaments of the wrist the anterior is the strongest, while the posterior is the most feeble.

Position.—The surgeon sits facing the patient's forearm, which is abducted horizontally and with the hand pronated. An assistant stands facing the operator, and with his back to the patient's shoulder. He steadies the limb, draws up the soft parts, and takes charge of the flaps as they are formed. He can also manipulate the hand if required. A second assistant may conveniently attend to the sponging.

The following methods of disarticulating will be described :—

1. Circular.
2. By elliptical incision.
3. By long palmar flap.
4. By external flap (Dubreuil's operation).

1. **The Circular Method.**—The circular incision is some way below the joint, and is inclined a little lower down upon the radial than upon the ulnar side, in order that the outer styloid process may be well cleared.

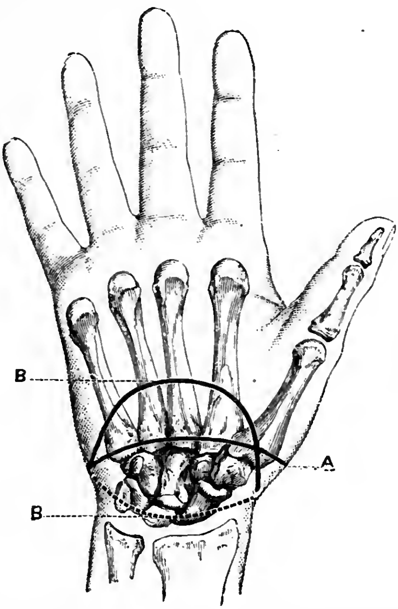

FIG. 367.—A, Palmar incision in the circular disarticulation at the wrist; B B, Incisions in the elliptical disarticulation at the wrist.

The incision on the inner side is just above the base of the fifth metacarpal bone, while on the outer side it crosses the first metacarpal about 1 cm. below the carpo-metacarpal joint of the thumb (Fig. 363, L, and Fig. 367, A).

The surgeon, holding the patient's hand in his left hand, makes the circular incision, commencing it upon the dorsum, and turning the hand from the prone to the supine position as the knife travels round the limb. The incision concerns at first the skin and the subcutaneous tissues only, and as it is being made

the assistant draws up the soft parts of the dorsum. The hand is now allowed to drop into the prone position, while the operator dissects up the integuments of the dorsum until the joint-line is reached and the styloid processes are cleared. The left fingers are used to assist in this retraction.

The surgeon once more grasps the pronated hand, and flexing the wrist to the utmost, divides the left lateral ligament (i.e. the ligament on the operator's left). By continuing the incision transversely, all the extensor tendons are severed opposite the line of the articulation, the joint is opened, and finally the right lateral ligament is cut. Still flexing the wrist, and so rotating the hand that the border on the surgeon's right is turned well forward, the operator cuts the anterior ligaments close to the carpus, and clears the bony eminences at the root of the palm. Unless care be taken, the pisiform bone is very apt to be left behind.

Little now is left but the mass of the flexor tendons. These are dragged upon while the wrist is still forcibly flexed, and the knife having been passed between the carpus and the tendons in question, the limb is finally severed by cutting vigorously from within outwards. In the final cut the palmar incision is, of course, followed. The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial artery is divided in the dorsal wound at its outer extremity. At the inner angle of the dorsal wound the carpal branch of the ulnar may be found bleeding. In the palmar wound are divided the superficial and deep portions of the ulnar artery on the inner side and the superficialis volæ on the outer.

2. **The Elliptical Method.**—So far as the covering of the bones is concerned, this method is nearly equivalent to disarticulation by a palmar flap. The position of the patient and of the operator are the same as already indicated.

The blade of the knife should be four inches in length.

The highest point of the ellipse is on the dorsum, a little to the inner side of the middle line, and half an inch below the line of the wrist-joint.

The lowest point is on the palm, in a line with the middle finger, and about two inches below the level of the highest point.

In forming the ellipse between these two points the incision on the ulnar side should pass between the pisiform bone and the base of the fifth metacarpal, while on the radial side it should cross the carpo-metacarpal joint of the thumb (Fig. 367, B).

The surgeon, holding the subject's hand in the supine position, marks out the palmar part of the ellipse, commencing the incision on the left side (the surgeon's left) of the hand. He now pronates the hand and marks out the dorsal segment of the ellipse, the assistant at the same time drawing up the integuments at the back of the hand. The first incision concerns the skin and the subcutaneous tissues only.

The remaining steps of the operation are nearly identical with those of the circular method.

The integuments on the dorsum are separated up until the styloid processes and the joint-line are cleared.

The surgeon, holding the pronated hand in the position of forced flexion, now divides in order the lateral ligament on the left, the extensor tendons and posterior ligament, and the lateral ligament on the right. The tendons are divided immediately opposite to the articulation, which is thus freely opened.

The anterior ligament is now severed close to the carpus.

The hand, still hanging down in the position of pronation and flexion, is so rotated that one or other border is turned forwards so as to face the surgeon. While in this position the lateral parts of the ellipse are deepened towards the palm, and the two bony eminences at the root of the palm are cleared, the knife being kept close to the bone.

The instrument is held vertically, with its point downwards, and is passed between the mass of the flexor tendons and the hollow of the carpus. With the knife held in this position the "carpal canal" is cleared out. Nothing now remains but to divide the flexor tendons and the surrounding soft parts. The tendons are dragged upon and are cut obliquely from within outwards, the knife—now held horizontally—finally following the existing cutaneous incision.

When the wound is adjusted, the cicatrix appears as a curved line upon the dorsum.

Hæmorrhage.—The radial artery is cut in disarticulating, and is found divided at the outer extremity of the dorsal wound.

It is severed above the origin of the branches to the thumb and index finger. In the inner portion of the palmar flap the ulnar artery is divided as it is forming the commencement of the superficial palmar arch. Deeper in this part of the palmar flap the deep branch of the ulnar artery is cut. In the outer segment of the palmar flap the superficialis volæ will be found severed. The deep palmar arch and the greater part of the superficial arch are, of course, removed with the hand.

3. **By a Long Palmar Flap.**—The flap is U-shaped. It commences half an inch below the radial styloid process, and ends half an inch below the tip of the corresponding process of the ulna. The outer limb is directed towards the gap between the index and middle fingers, the inner limb towards the web between the little and ring fingers.

The almost transverse extremity of the flap reaches nearly to the middle of the metacarpus. Its general outline is shown in Fig. 368. The dorsal incision is carried straight across the back of the limb from one extremity of the palmar flap to the other. It will therefore cross the carpus.

A stout knife with a blade some three inches in length is required.

The operator grasps the patient's hand and holds it in the position of extension and supination. Entering the knife half an inch below the styloid process to his left, he carries it across the palm, in the direction indicated, to the corresponding point on the other side of the hand, and thus marks out the palmar flap.

An assistant now takes the hand and retains it in the same position, while the operator proceeds to dissect up the great flap. This should include all the soft parts down to the flexor tendons. A considerable portion of the muscles of the thenar and hypothenar eminences will consequently form a part of the flap, and the limb of the superficial palmar arch will be divided at its free end.

The flap should be dissected up to the level of the radio-carpal joint, care being taken to clear the bony prominences in the palm of the hand.

The surgeon now takes the hand and holds it in the pronated position, while the assistant draws up the skin on the back of the limb. The dorsal incision is made. The integuments are

dissected up to the joint-line, and the extensor tendons and the ligaments of the wrist are divided precisely as in the previous operation. Nothing now connects the disarticulated hand with the forearm but the mass of the flexor tendons and the tissues about them. These are drawn upon and divided by a vigorous transverse cut made from above downwards—i.e. from dorsum to palm—care being taken that the palmar flap is held well out of the way at the time.

The palmar flap should never be cut by transfixion. The bony prominences in the palm render such a method difficult, and an unduly scanty flap is apt to result.

Hæmorrhage.—The vessels are divided as in the previous operation. The deep palmar arch and the transverse part of the superficial arch are removed with the hand.

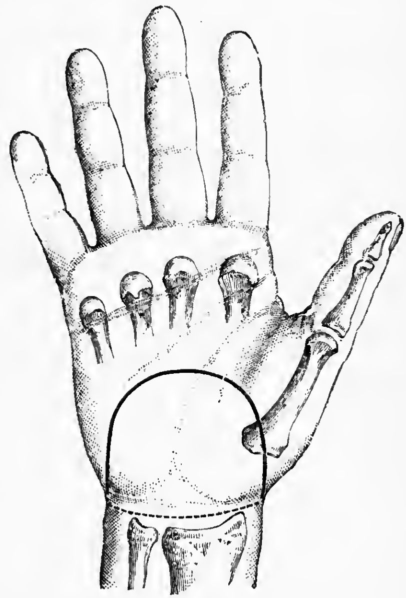

FIG. 368.—DISARTICULATION AT THE WRIST BY LONG PALMAR FLAP.

4. **Dubrueil's Operation by an External Flap.**—This ingenious method is thus described by Chalot (*Chirurgie Opératoire*, 1886), who states that he has seen excellent results from this operation in the hands of Professor Dubrueil :—

"The incision is commenced on the back of the wrist, at the junction of the outer with the middle third, and at a point half a centimetre below the line of the wrist-joint. It is thence carried downwards towards the thumb upon the dorsal aspect of the limb, and is made to cross the first metacarpal bone transversely about its middle. The incision now follows the inner part of the thenar eminence, and terminates at a point diametrically opposite to the point at which it was commenced. This represents the outline of the external or thenar flap (Fig. 364, G).

"This flap is now dissected up to its base, and is made to include as much of the thenar mass of muscle as is possible. The skin and

soft parts internal to the flap are then divided in a circular manner through an incision on a level with the base of the flap. Disarticulation having been effected, the operation is complete. The thenar flap is brought transversely across the face of the radius and ulna, and is there secured."

Comment.—Disarticulation may also be effected by a *long dorsal flap*. This flap has its base at the styloid process and its extremity opposite the centre of the metacarpus. The method has little or nothing to recommend it. The flap is composed only of skin and tendons, is very retractile, and very poorly supplied with blood. It affords a scanty covering for the bones, and either the integuments or the underlying tendons are apt to slough. If the flap be composed of skin only, its fate is nearly certain.

The amputation by *equal palmar and dorsal flaps* corresponds to the circular method, with the addition of a lateral incision extending downwards from each styloid process.

The value of disarticulation at the wrist has been much discussed, and by some of the older surgeons it is advised that in the place of this operation an amputation should be performed through the lower end of the forearm. The objections urged against the disarticulation are the following:—1. The mortality is said to be high. 2. The cartilage, if left on the radius, is said to necrose. 3. The resulting stump is said to be ill-adapted for the adjustment of an artificial hand.

1. The mortality after disarticulation of the wrist is decidedly lower than the mortality after amputation of the forearm.

2. If the cartilage be sound, and the wound be treated antiseptically, there is not the least fear of exfoliation.

3. This assertion does not hold good at the present day. The stump after a successful disarticulation at the wrist is better adapted for the adjustment of a useful artificial hand than is the stump low down in the forearm.

In disarticulation the movements of pronation and supination are usually retained. In forearm amputations those movements are lost.

In the matter of the *technique of the operation* attention may be drawn to the following points:—

The disarticulation is always more readily effected from the dorsum. In dissecting up the palmar tissues, it is not easy to avoid removing the pisiform bone with the soft parts. It will often be found more convenient to include it in the tissues of the palmar flap, and to remove it subsequently by dissection.

In planning any operation, account must be taken of the very great retractility of the dorsal tissues, and of the difficulty of properly covering the radial styloid process.

The lower ends of the radius and ulna should not be sawn off. If this be done the pronation and supination movements will be lost, and the attachment of an important flexor—the supinator longus—is disturbed.

Of the operations described, the best procedure is undoubtedly the *elliptical method*. The cicatrix falls upon the dorsum, the bones are well covered, and the free end of the stump is made up of the tough and well-nourished tissues of the palm. The styloid processes are well protected.

The operation by a *palmar flap* may rank next in order of value. It has these disadvantages when compared with the elliptical operation: The tissues of the palm are more extensively encroached upon; the flap is of a somewhat awkward shape, and, as it includes the tougher parts of the palmar integuments, it is a little unyielding and stiff, and not so readily adjusted as is the smaller and less rigid flap of the elliptical method. The flap, moreover, contains more fatty tissue, and healing after the operation is usually a little slow—a circumstance to which the occasionally horny condition of the skin and the difficulty of perfectly disinfecting it may no doubt contribute.

In the palmar flap operation the incisions are carried comparatively high up on the sides of the limb, and there is a little more disposition for the styloid processes to be exposed when the flap is adjusted.

The *circular operation* has the merit of being readily performed. It affords, however, a somewhat scanty covering to the bones, and the cicatrix is placed at the extremity of the stump and over the prominences of bone. If the tissues of the palm or of the dorsum have been thickened by inflammation, there may be some difficulty in dissecting up the covering of soft parts.

Dubrueil's operation is ingenious, and is said to yield excellent results. A good covering is provided for the bones, and especially for the radial styloid process. The flap is substantial, and is well nourished with blood-vessels.

The operation is well adapted for cases of injury or disease, where the palmar and dorsal tissues are so damaged as to render any of the three first-named procedures inadmissible.

It is, however, but rarely that this form of amputation can be indicated, as it is certainly inferior to the method by anterior flap. I (J. H.) had once the opportunity of performing it on a man who had deliberately placed his hand under a tramcar. The skin over the back of the thumb was the only part of the hand not destroyed, and by utilising this it was possible to avoid amputation higher than the wrist. The narrow flap contracted somewhat, but the result was satisfactory.

After-treatment of Disarticulation of the Wrist.—The rigidity and thickness of the palmar tissues render it necessary that in the elliptical or palmar flap operation the sutures should be very securely applied, and should not be too early removed. They should take a hold of the entire thickness of the palmar tissues.

In all instances the stump should be placed upon a short and light palmar splint. In the case of the two operations just named the splint serves to support the palmar flap, and in all disarticulations at this joint it serves to prevent pronation and supination movements.

The possibility of an accumulation of pus in the remains of the synovial sacs for the flexor tendons must be borne in mind, should suppuration take place.

A drainage-tube should be inserted, and retained for thirty-six or forty-eight hours.

II. AMPUTATION THROUGH THE FOREARM

A very large number of different operations have been described under this heading, and there is probably no known method of cutting flaps that has not been recommended as especially suitable to amputation of the forearm.

The fact that the limb undergoes a considerable change in its

configuration and physical characters between the elbow and the wrist has no doubt excused the multiplicity of methods.

In the account which follows, two operations will be described, the first that which appears best adapted for the lower third of the limb, the second one well suited for the upper two-thirds.

Anatomical Points.—At its upper half, and especially in its upper third, the limb is much wider in its transverse than in its antero-posterior diameter. A horizontal section through this part will show a cut surface which is somewhat oval in outline, and is at the same time flattened in front and more convex behind. This outline is best seen in muscular subjects, and depends chiefly upon the development of the lateral masses of muscle which descend from the condyles.

In the non-muscular, the limb, even in its highest parts, tends to assume a rounded rather than an oval outline.

The ulna is subcutaneous throughout its entire extent. The upper half of the radius is deeply placed, while the lower half is superficial. Transverse sections of the limb at various levels show that the radius and ulna are in all parts nearer to the posterior than the anterior aspect of the extremity. This relation is the more marked the higher up the section. The two bones are nearest to the centre of the limb about the lower end of the middle third. In antero-posterior flaps cut by transfixion, the anterior flap will consequently be always the more substantial.

At the upper part of the forearm the muscles are found mainly at the sides and in front. The lower the section proceeds down the limb, the less will the bones be covered at the sides, and the more equally will the soft parts be found distributed along the anterior and posterior aspects of the limb. Thus it follows that the circular method is best adapted for the lower third of the forearm, and the flap method for the upper two-thirds. It will be obvious also that if antero-posterior flaps be cut of equal width, the bones, in the lateral incisions, will have a greater disposition to protrude in the lower part of the limb than in the upper.

It will be noticed that where one bone is the most substantial the other is the most slender, as near the elbow and wrist; and that it is about the centre of the limb that the two are most nearly of equal strength.

The interosseous space is narrowest in full pronation and widest in supination. It is only in the mid-position that the bones are parallel to one another.

There is a singular absence of large blood-vessels and nerves along the posterior aspect of the forearm.

The three chief pronator muscles are the pronator teres, pronator quadratus, and flexor carpi radialis.

The three chief supinators are the supinator longus, supinator brevis, and the biceps. If, therefore, the bones—in an amputation—be divided above the insertion of the pronator teres, the radius will become supinated, and further rotation movements will be lost.

The brachial artery divides opposite to the neck of the radius, and the ulnar gives off the interosseous trunk one inch below this point.

Instruments.—An amputating knife, with a blade four to five inches in length. A stout scalpel. An amputating saw. Retractors (the linen retractor used to protect the soft parts during the sawing of the bones may have three "tails," the middle and narrowest slip being passed through the interosseous space). Pressure and dissecting forceps. Scissors, needles, etc.

Position.—The arm is abducted, and the surgeon stands to the right of the limb in all cases—i.e. to the outer side of the right forearm and the inner side of the left.

One assistant—to the operator's left—steadies the upper arm and retracts the flaps, etc. The other—to the operator's right—manipulates the forearm and hand, and attends to the sponging, etc.

The following operations are described :—

1. Circular method.
2. Equal anterior and posterior flaps.
3. Methods less frequently employed.

1. **The Circular Method** (*through the lower third*).—The position of the incision is estimated in the usual way. The circular cut in the skin will be placed at a distance below the future saw-line equal to the antero-posterior diameter of the limb at that line.

The patient's limb is held in the supine position.

The surgeon, passing his hand beneath the patient's forearm, commences the incision on that border of the limb which is the nearer to him, and uses the heel of the knife for the purpose. The knife is now drawn from heel to point across first the flexor and then the extensor aspect of the limb, until it reaches

the point at which the incision was commenced. During this manœuvre the operator grasps the forearm above the incision with his left hand. A cuff of skin is now dissected up, and turned back as shown in Fig. 356, and this retraction of soft parts should be continued until the level of the future saw-line is reached. Throughout, the limb is kept with the hand supine, but the elbow should be flexed so as to render the forearm vertical while the posterior part of the *manchette* is being dissected up.

The forearm being extended, with the hand supine, the soft parts on the flexor side of the limb are transfixed by the knife, which is so passed transversely across the forearm that its point is made to enter and emerge at the level of the retracted skin. The knife should follow the curve of the bones, so as to take up as much of the tissues on the front of the limb as possible. It is now made to cut its way abruptly out, so that the muscles and tendons shall be divided transversely a little below the future saw-line.

The soft parts on the extensor side of the limb are transfixed and divided in precisely the same way, the limb being still kept in the same position during the process. While the flexor tissues are being cut, the hand is kept a little extended; and while the tissues on the extensor side of the limb are being cut, the hand is a little flexed.

The soft parts might be divided—as is usual—by a circular sweep with the knife at the level of the retracted skin; but as the structures to be severed are for the most part tendons, they are much more easily and more cleanly divided by cutting from within outwards, as advised. With a scalpel any remaining soft parts are now separated from the bones until the saw-line is well exposed, and at this level the interosseous membrane is divided transversely. The retractor having been applied, the bones are sawn through. In dividing the bones it is convenient to have the hand placed in the mid-position between pronation and supination, and to saw the radius first and then the ulna. Many operators keep the hand supine, and endeavour to divide the two bones evenly and at the same time.

Hæmorrhage.—On the face of the flexor part of the wound are found divided the radial and ulnar arteries. The former, no

longer accompanied by the radial nerve, lies close to the radius and to the inner side of the conspicuous tendon of the supinator longus muscle.

The ulnar artery will be found lying on the flexor profundus digitorum and under cover of the flexor carpi ulnaris. The nerve is to its inner side. Behind the interosseous space, and between the superficial and deep muscles, the posterior interosseous artery may be found bleeding, and in front of that membrane the anterior interosseous, and possibly the median.

2. **By Equal Antero-posterior Flaps** (*through the upper two-thirds*).—The base of each flap should be equal to half the circumference of the limb at the level of the saw-line.

The length of each flap should be equivalent also to half the circumference after the usual allowance has been made for retraction. Thus, to take the measurements recommended by Farabeuf, if the circumference of the limb in pronation be 80 mm., each flap should, after retraction, measure 40 mm.; and to allow for such retraction its length, as marked out upon the skin, should be 60 mm.

The flaps are U-shaped, and the lateral incisions correspond to the lateral margins of the limb. The anterior flap will contain the supinator longus and the flexor muscles. The posterior flap will contain the extensors. In the radial incision the vertical cut will involve the two extensors of the radial side of the carpus. In the lateral ulnar wound the flexor profundus and the flexor carpi ulnaris are found to be marked by the vertical incision.

The hand having been supinated, the anterior flap is marked out by a skin-cut. In the case of the right limb, the knife is entered at the commencement of the ulnar incision, is carried down along the ulnar border, and is then made to sweep transversely across the flexor surface of the limb. The knife being withdrawn, its point is entered at the upper end of the radial incision, and is carried down along the radial border of the forearm to meet the first incision. The flap is marked out therefore by two cuts, and the incision is commenced on the side more remote from the surgeon. In the left limb the knife is first entered upon the radial border.

The elbow being now flexed so that the forearm is vertical (the hand being still supine), the posterior flap is marked out in the integuments only. The skin thus fashioned for the future flaps is allowed to retract. The forearm is now again held horizontally, with the elbow a little flexed and the hand still supine. The operator lifts up the tissues on the front of the limb with the fingers of the left hand, and proceeds to transfix. The knife is entered at the angle of the wound nearest to the surgeon, and is made to follow as accurately as possible the curves of the bones and the interosseous membrane. Its point should just graze the bones as it moves across the limb.

While the assistant extends the hand, the surgeon cuts a muscular flap from within outwards, bringing the knife out sharply just at the level of the retracted skin. The posterior flap is cut by transfixion in the same way, the limb being held in the same posture. It is difficult to insinuate the knife behind the ulna, and its movements in that position must be assisted with the left fingers. While the muscular tissue is being divided, the assistant flexes the hand. The two flaps are now drawn up to the level of the saw-line, and the remaining soft parts are divided at that level to clear fully the bones.

FIG. 369.—THE "INCISION EN 8 DE CHIFFRE."

The black and white arrows mark the course of the knife.

This is effected by what the French surgeons call the "*incision en 8 de chiffre*" (Fig. 369). The knife is made to so pass across the front and back of the limb as to follow the outlines of the bones and to sever well the interosseous membrane. The hand is kept supine, and both the anterior and posterior incisions are made from left to right, and both are commenced by the heel of the knife and completed by its point.

The threefold retractor having been applied, the bones are sawn in the manner already described.

Some surgeons advise that the median, ulnar, and radial nerves should be resected from the anterior flap.

Hæmorrhage.—The radial artery will run the whole length

of the anterior flap, and be cut near its outer border on the inner side of the supinator longus. The radial nerve accompanies it. The ulnar artery will be cut shorter, will be in front of the bone, and between the flexor sublimis and flexor profundus digitorum. The anterior interosseous vessels will be divided immediately in front of the interosseous membrane. The posterior interosseous artery will be cut long, and will be found between the superficial and deep muscles.

The more conspicuous nerves form good guides to the divided vessels.

3. **Other Methods.**—(1) *By Long Anterior Flap.*—This flap will measure in an adult's forearm some four and a half inches in length. The posterior flap is one half the length of the anterior. They may be cut in the manner just described.

(2) *By Long Posterior Flap.*—This consists in the application of Teale's method to the forearm, and has been adopted for amputations above the wrist. In practising the operation, care must be taken to mark out the flaps by measurement before attempting to cut them, as otherwise, from the conical shape of the limb, the long flap will be apt to be made too narrow at its distal extremity.

If the posterior flap be carried below the wrist-joint, its lower part must consist of skin only, as it is scarcely possible to extricate the tendons from the bony grooves behind the radius.

As this flap is large, and is composed only of tendons and of very thin and retractile skin, and inasmuch as it contains no blood-vessels of any magnitude, it is apt to shrink considerably, to slough, and to form in any case a scanty covering for the bones.

The operation has little therefore to recommend it.

(3) *By Skin-flaps with Circular Division of Muscles.*—Mr. Jacobson is of opinion (" Operations of Surgery ") that no method, on the whole, answers so well as this.

The posterior skin-flap is about three inches in length, the anterior two inches. The muscles are divided by a circular sweep at the base of the flaps.

Comment.—The circular method is well adapted for the lower third of the limb, and is no doubt the best amputation in that situation. The soft parts here being composed mainly of integument and tendons, sound flaps cannot well be cut.

It has been urged against the circular operation in this place that there is a tendency for the cicatrix to adhere to the bone. If the bones be well covered, and the healing be by first intention, this objection can have little weight. Such adhesion could be avoided, however, by replacing the circular amputation by the method last described, i.e. amputation by unequal antero-posterior skin flaps with a circular division of muscles.

In the upper two-thirds of the limb the circular method is not admissible, unless it be in wasted subjects. Under normal conditions, the outline of the limb, the great mass of muscle, and its intimate adhesion to the bones are objections to this operation. Unquestionably the two-flap method is the best here, and if it is advisable to make one flap larger than the other it should always be the anterior one—as being more muscular and better supplied with arteries.

CHAPTER IV

AMPUTATIONS THROUGH ELBOW AND ARM

I. DISARTICULATION AT THE ELBOW-JOINT

THIS operation is not frequently performed, and has been condemned by many as an unsound surgical proceeding. The amputation—although it has met with little favour in England—has been extensively practised by French surgeons, by whom, moreover, the principal methods have been devised.

It has been urged against the operation that it is more difficult and less safe than an amputation through the lower part of the arm ; that the soft parts have to be divided very low down in order to secure a covering for the bones ; that many vessels—those forming the anastomotic plexus about the joint—are divided ; that the cartilage may exfoliate ; and that a stump is left which is ill-adapted for an artificial limb.

Some of these objections are ill-founded, others have disappeared with the advance of surgical science.

The disarticulation, although not really difficult, is certainly less easy than an amputation through the arm, which is one of the simplest operations of the kind. Before the development of antiseptic surgery the mortality after this disarticulation was terrible. The statistics derived from the records of the Crimean War show the deaths to have been over 50 per cent. On the other hand, the statistics of the American War produced a mortality from the operation of less than 8 per cent., and in the Boer War it was still lower.

It is true that to protect the bones properly a considerable covering of soft parts is required. At the same time the flaps may be cut in so many ways that the methods employed adapt themselves to a great variety of conditions.

Several vessels are divided, but they are small, and as a rule not more than three ligatures are required.

The cartilage should never exfoliate, provided that it is sound, and that the wound is treated upon antiseptic principles.

The stump is much better adapted for the application of an artificial limb than is that resulting from an amputation of the arm. French surgeons speak very highly of this operation, and are emphatic as to its value.

Anatomical Points.—On the anterior aspect of the elbow are seen three muscular elevations. One, above and in the centre, corresponds to the biceps and its tendon ; while of the two below and at the sides, the outer corresponds to the supinator longus and the common extensor mass, and the inner to the pronator teres and the common set of flexor muscles.

The biceps tendon can generally be very distinctly felt. The crease in the skin known as the "fold of the elbow" is convex below, and is placed some little way *above* the line of the articulation. Its lateral terminations correspond to the tips of the two condylar eminences. The points of these eminences are always distinct. The inner condyle is the more prominent and the less rounded of the two. The humero-radial articulation forms a horizontal line, but the humero-ulnar joint is oblique, the joint-surfaces sloping downwards and inwards. The external condyle is three-quarters of an inch above the articular line, while the point of the inner condyle is more than one inch above that part.

A line drawn through the two condyles is at right angles with the axis of the upper arm, but forms an angle with the axis of the forearm. The joint-line of the elbow is equivalent only to about two-thirds of the width of the entire line between the points of the two condyles. Between the olecranon and the inner condyle is the depression which lodges the ulnar nerve and the posterior ulnar recurrent artery. To the outer side of the olecranon, and just below the external condyle, there is a depression in the skin, in which the head of the radius can be felt and the interarticular interval made out. The pit corresponds to the hollow between the outer border of the anconeus and the muscular eminence formed by the two radial extensors of the carpus and the supinator longus.

The skin about the elbow-joint is thin. In front it has a most remarkable disposition to retract after division, and this

especially applies to the skin over the radial border of the limb. The integument at the back of the joint is loose, has but little tendency to retract, and is well adapted to bear pressure.

The brachial artery bifurcates about a finger's-breadth below the centre of the bend of the elbow. The details of the plexus of anastomosing arteries about the joint should be borne in mind. For a hand's breadth below the olecranon there is almost an entire absence of superficial veins.

Of the ligaments of the elbow-joint the internal is the most substantial, the external ranking next. The anterior and posterior ligaments are both thin.

In disarticulating, it is well to remember that the triceps is attached not only to the summit of the olecranon, but also to its sides, and that the brachialis anticus is inserted into the ulna beyond the coronoid process.

In children under ten the whole of the upper part of the olecranon is cartilaginous. The lower epiphysis of the humerus joins the shaft at seventeen, with the exception of the part forming the internal condyle, which joins the shaft at eighteen.

Instruments.—An amputating knife some six to seven inches in length for transfixion operation. A stout knife with a cutting edge of four to five inches, when flaps are cut from without inwards, and for disarticulating. A scalpel; retractors; pressure, artery, and dissecting forceps; scissors, needles, etc.

Position.—The arm is abducted to a right angle. The surgeon—except in an instance below specified—stands to the right of the limb in all cases, i.e. to the outer side of the right elbow and the inner side of the left.

One assistant, standing to the operator's left and near the patient's shoulder, steadies the arm, retracts and supports the flaps, etc. The other, to the surgeon's right, holds and manipulates the hand and forearm.

The following methods will be described:—

1. The circular.
2. The elliptical.
3. The large anterior flap.

1. **Circular Method.**—In order to prepare for the unequal retraction of the skin, the incision must be a little oblique.

Over the supinator longus it should be about three inches below the joint-line, and over the posterior border of the ulna one inch and a half below that level (Fig. 370).

Grasping the arm with his left hand, while an assistant holds the forearm, the surgeon makes the circular incision with one sweep. He begins with the heel of the knife and upon the side

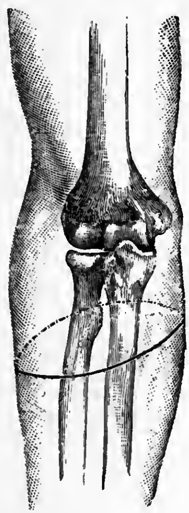

FIG. 370. — DISARTICULATION AT THE ELBOW-JOINT BY CIRCULAR METHOD.

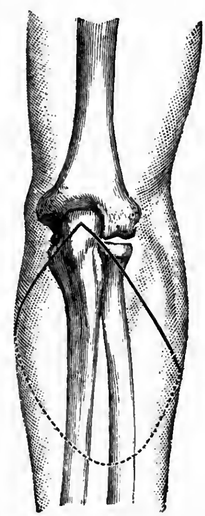

FIG. 371.—DISARTICULATION AT THE ELBOW-JOINT BY THE ANTERIOR ELLIPSE METHOD.

of the limb nearest to him, and in order to reach that side he passes his own forearm beneath the patient's limb.

The incision involves the skin only, and the integuments are allowed to retract. When retraction has taken place, the skin ceases to appear to have been divided obliquely. When the integuments have been retracted to a point about one inch below the line of the articulation, the superficial muscles are divided by a circular sweep at that level. The skin is further retracted until the condyles are reached, and the deeply-placed muscular tissue which is still undivided is cut immediately over the joint. An assistant draws up the divided parts.

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The surgeon now grasps the forearm with his left hand. and, keeping the elbow fully extended, cuts the anterior ligament and then the lateral ligaments ; or he may directly enter the joint from the outer side by dividing the external ligament. Nothing now connects the limb with the trunk but the posterior ligament and the triceps. The tendon of that muscle is the last structure severed.

The skin which formerly covered the olecranon now forms a pouch, and an opening for a drainage-tube should be made in the centre of this depression. The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial and ulnar arteries will be divided just below their point of origin, or the brachial will be severed close to the bifurcation. In front of the outer condyle the superior profunda, lying by the musculo-spiral nerve, may require a ligature, and the same applies to the termination of the inferior profunda behind the internal condyle.

2. **Elliptical Methods.**—This operation may be performed in one of two ways :—

(1) *Anterior Ellipse* (*Farabeuf*).—The figure described by the incision is rather lozenge-shaped than elliptical.

The highest point of the ellipse is behind, over the prominence of the olecranon. The lowest point is on the anterior surface of the limb, over the eminence formed by the supinator longus, and at a spot a little above the middle of the forearm (Fig. 371).

In performing this operation the surgeon may conveniently stand to the left of the limb to be removed, i.e. to the inner side of the right forearm and the outer side of the left. The elbow will be on his right hand, the hand on his left. The elliptical incision may be made in one sweep from olecranon to olecranon.

Holding the wrist in his left hand, and flexing the elbow a little, the surgeon so rotates the limb as to turn the farther side of the forearm towards him. (This will be the radial margin on the right limb, and the ulnar margin on the left.) He carries the incision downwards from the olecranon to the lower extremity of the ellipse. As the knife crosses the anterior aspect of the limb, the forearm is kept extended, with the hand supine.

The elbow is once more flexed, and the limb is now so held as to bring uppermost the border of the forearm nearest to the surgeon. The knife is carried upwards across the border to terminate at the point of commencement over the olecranon (Fig. 371). The incision involves the skin only.

An assistant now takes the forearm, while the surgeon separates and retracts the integuments a little all round.

This retraction will shorten the anterior flap about one inch and a half.

The elbow being a little flexed, and the hand supine, the operator pinches up the soft parts on the flexor aspect of the

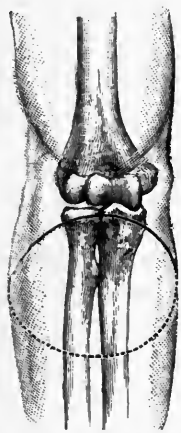

FIG. 372.—DISARTICULATION AT THE ELBOW-JOINT BY THE POSTERIOR ELLIPSE METHOD.

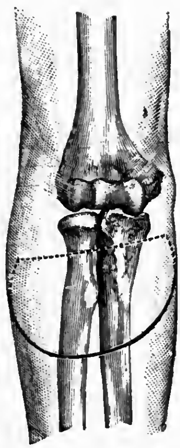

FIG. 373.—DISARTICULATION AT THE ELBOW-JOINT BY ANTERIOR FLAP.

bones with the left hand, and then transfixes the limb transversely. The knife should be entered as near the joint as possible, and should pass close to the anterior surfaces of the radius and ulna. The muscles are cut obliquely, and an anterior flap is thus formed. An assistant draws up this flap, and the surgeon, keeping his knife close to the bones and almost flat, cuts upwards until the anterior aspect of the joint is reached.

Nothing now remains but to disarticulate in the manner already described, and to divide the triceps and any tissues which have escaped division along the lateral and posterior aspects of the limb.

A curved cicatrix on the posterior aspect of the limb results.

Hæmorrhage.—In addition to muscular branches, divided with the cut muscles, the radial and ulnar arteries will be found severed near the free end of the anterior flap ; and on the deep surface of that flap the interosseous artery, and possibly the posterior ulnar recurrent, may require ligature. Bleeding may also occur from the terminations of the superior profunda in front of the external condyle, and of the inferior profunda behind the inner condyle.

(2) *Posterior Ellipse* (*Soupart*).—In this operation the highest point of the ellipse is in front and the lowest point behind. The flap is therefore taken from the posterior aspect of the limb (Fig. 372).

The procedure is thus described by Ashhurst (" Encyclopædia of Surgery," vol. i., page 640), who considers the method to be " upon the whole the best " :—

" The arm being semi-flexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upwards over the front of the forearm nearly to the line of the joint, and downwards again to a point an inch and a half below the external condyle. The arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon.

" The cuff thus marked off is rapidly dissected upwards as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side.

" The brachial artery is divided, and other vessels may be severed as in the circular operation.

" The wound is closed transversely, and leaves a small curved cicatrix in front of the bone."

3. **By Large Anterior Flap.**—The base of the flap should represent more than half the circumference of the limb, and should be **U**-shaped.

The anterior incision should commence three-quarters of an inch below the line of the joint on the inner side, and one inch

and a half below that line on the outer side. The extremity of the flap (the curve of the U) should reach some three inches below the articulation.

The posterior incision is made to connect directly the extremities of the anterior incision (Fig. 373).

The position of the operator has been already indicated (page 528). The anterior flap should be marked out by a skin incision, the limb being at the time extended and the hand supine, and the knife should be entered upon the border of the forearm most remote from the surgeon. The muscular part of the flap is cut by transfixion, precisely as in the anterior elliptical method. The flap is drawn up and the posterior incision made. The operation is completed as in the disarticulation by the anterior ellipse, and the blood-vessels are divided in the same manner.

Many surgeons cut a short posterior flap about one-half or one-third the length of the anterior flap.

Comment.—Several methods of disarticulating at the elbow-joint have been advised or practised, in addition to those described. Among these may be mentioned the amputation by lateral flaps, the external being the larger; by antero-posterior flaps, the anterior predominating; and by a racket incision, the *queue* of which is over the olecranon.

In estimating the comparative value of the methods described, it will be observed that collectively they meet almost every condition of limited or unequal lesion in which the selection of flaps has to be influenced by the position of the damaged parts.

The *elliptical method*—and notably the amputation by the anterior ellipse—is on the whole the best, provided, of course, that the tissues upon the flexor side of the limb are sound.

Inasmuch as, in cases of accident demanding disarticulation, the damage to the soft parts is very often upon the posterior aspect of the joint, the operation is of extensive application.

The flap is well supplied with blood, and provides an excellent covering for the bone. Efficient drainage is permitted, and there is no skin-pouch left over the region occupied by the olecranon. The cicatrix is removed from the extremity of the stump. A considerable demand is made upon the tissues on

the front of the limb, and there is an extensive division of muscle substance.

The operation by the *anterior flap* has the main advantages of this method, and also its disadvantages. It provides, however, a less efficient covering for the condyles, and the olecranon pouch is left. It makes, on the other hand, less demand upon the tissues on the front of the limb.

The amputation by the *posterior ellipse* provides a covering for the bone composed of skin accustomed to withstand pressure. The flap is, however, somewhat scanty, and of uneven thickness. It is not well supplied with blood, and the conditions of the stump are by no means well adapted for efficient drainage.

The *circular operation* is a little difficult to perform. It involves but a comparatively small sacrifice of parts. The main artery and the muscles are squarely cut, and the whole wound surface is consequently small. Excellent drainage is afforded. The end of the humerus is, on the other hand, somewhat scantily covered, and the cicatrix occupies the free extremity of the stump.

After-treatment of Disarticulations at the Elbow.—There is nothing noteworthy with regard to the after-treatment of these operation wounds except the following :—

The stump should be kept raised upon a supporting pillow.

As some of the flaps are bulky, and not disposed to fall into place, substantial sutures are required, and these should not be too early removed.

There is usually so considerable a discharge provided by the synovial membrane that the stump should be drained with a tube. The tube, in an ordinary case, need not be retained for longer than forty-eight hours.

II. AMPUTATION OF THE ARM

The surgical rule that the least possible amount of the limb should be removed by amputation applies conspicuously to the upper arm.

Even the short stump left when the bone is sawn through at the surgical neck is better than that left by disarticulation at the shoulder-joint. The operation not only involves less risk to the patient, but affords a valuable point of attachment for an artificial limb.

Anatomical Points.—In women, and in those who are fat, the outline of the arm is rounded and fairly regular. It is less regular in the muscular, in whom it may be represented by a cylinder somewhat flattened on either side and unduly prominent in front (biceps muscle).

The outline of the biceps muscle is distinct, and on each side of it is a groove. The inner of the two grooves is by far the more conspicuous. It runs from the bend of the elbow to the axilla, and indicates generally the position of the basilic vein and brachial artery. The outer groove is shallow, and ends above at the insertion of the deltoid muscle. So far as it goes, it marks the position of the cephalic vein.

The insertion of the deltoid can be well made out, and is an important landmark. It indicates very precisely the middle of the shaft of the humerus, is on the same level with the insertion of the coraco-brachialis muscle, and marks the upper limit of the brachialis anticus. It corresponds also to the point of entrance of the nutrient artery (which runs towards the elbow), and to the level at which the musculo-spiral nerve and superior profunda artery cross the back of the bone.

The brachial artery in the upper two-thirds of its course lies on the inner aspect of the shaft of the humerus ; in the lower third it is placed directly in front of the bone. The superior profunda arises near the outlet of the axilla, the inferior profunda opposite the centre of the humeral shaft, and the anastomotica magna about two inches above the bend of the elbow. The frequency with which variations in the brachial artery are met with should be borne in mind.

The skin is thin and smooth, especially on the inner side of the limb. It is upon this aspect of the limb also that it is the most retractile. The skin over the deltoid is to some extent adherent.

Below the middle of the arm the biceps is the only free muscle, the brachialis anticus and the triceps being both closely attached. Above the middle of the arm nearly all the divided muscles—the biceps, the deltoid, the coraco-brachialis, and the long head of the triceps—are more or less free and capable of retraction. While, therefore, the circular operation is well adapted for the lower part of the arm, it is ill suited for the upper segment.

The upper epiphysial line of the humerus is horizontal, and is placed a little above the surgical neck. The epiphysis joins the shaft at twenty.

Instruments.—An amputating knife equal in length of blade to one and a half times the width of the limb for transfixion.

A knife with a still longer blade for the circular method. A stout knife, some four inches in length, with which skin-flaps may be marked out and muscles separated from the bone. An amputating saw. Some seven or eight pressure forceps. Artery and dissecting forceps. Scissors, retractors, etc.

Position.—The patient lies upon the back, and near to one or other edge of the table, according to the side of the amputation.

The limb is horizontal, and is abducted until it is at right angles to the body. The surgeon stands to the outer side of the right arm and the inner side of the left. One assistant holds the hand and forearm, and manipulates the limb. A second stands above the surgeon, and attends to the retraction of the divided parts. A third assistant commands the main artery.

The following two methods will be described. The first-named is considered to apply especially to the lower half of the arm, the second to the middle of the limb :—

1. The circular method.
2. By antero-posterior flaps.

1. **The Circular Method** (*lower half of the limb*).—Fixing the arm with his left hand, the surgeon makes a circular sweep through the skin. To effect this he passes his hand beneath the limb, and bending his wrist over the patient's arm, he commences his incision with the heel of the knife, upon the surface of the limb nearest to himself (i.e. upon the outer surface of the right arm and the inner surface of the left). The assistant holding the forearm so rotates the limb as to make the tissues meet the knife.

The cut can be made to extend with one sweep around about three-fourths of the limb. The circle is completed by withdrawing the knife, and having entered it again at the point of commencement, the surgeon now cuts in the opposite direction —i.e. towards himself—and so incises the small tract of skin yet undivided (Fig. 374, A). The incision involves the skin only, and care must be taken that the knife does not pass deep enough to wound the brachial artery. The integuments are now separated, especially along the lines of the intermuscular septa, and the skin

thus freed is well and evenly retracted by the assistant. No "cuff" of skin should be turned back. In a stout or muscular arm the proceeding is almost impossible unless a lateral incision be made.

When the skin has been sufficiently drawn up, the biceps is divided about a thumb's breadth below the edge of the retracted

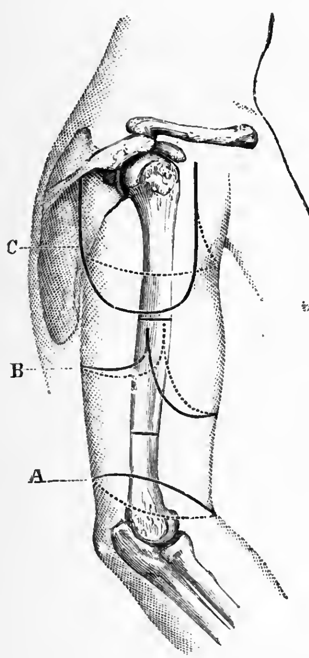

FIG. 374.—A, Circular (inclined) amputation of the arm; B, Amputation of the arm by antero-posterior flaps; C, Amputation at the shoulder-joint by deltoid flap.

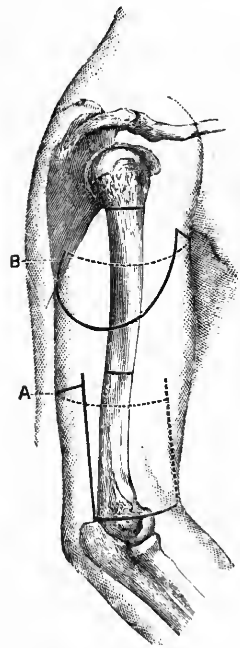

FIG. 375.—A, Amputation of the arm by Teale's method; B, Amputation through the surgical neck by single external flap.

skin. With a circular sweep of the knife the remaining muscular tissue is divided down to the bone, as close as possible to the edge of the divided integument. This circular cut is made in the same manner as the first incision in the skin. The assistant still further retracts the divided soft parts, until they appear as a kind of fleshy cone. A second circular incision is next made at the base of this cone, at the level of the now fully retracted integument. The knife is carried down to the humerus.

The bone is now cleared, the periosteum divided, the retractors are applied, and the shaft is sawn through. Before applying the saw, it is well to see that the musculo-spiral nerve is cleanly severed. It is apt to escape division, as it lies in the bony groove, and to be mangled by the saw.

The sutures are so applied that the cicatrix becomes vertical (antero-posterior), to ensure good drainage.

Owing to the fact that the skin upon the antero-internal aspect of the limb retracts more than does that upon the remaining part of the surface of the arm, it follows that the cicatrix after an ordinary circular amputation is not terminal, but is drawn forwards and inwards. To secure a terminal cicatrix, the circular incision should be not quite horizontal, but should incline lower down upon the antero-internal aspect, as shown in Fig. 374, A.

Hæmorrhage.—The vessels are divided upon the face of the stump—the brachial to the inner side with the median nerve; the superior profunda upon the postero-external aspect of the bone with the musculo-spiral nerve; the inferior profunda to the inner side of the brachial with the ulnar nerve. In addition to these three vessels, several muscular branches will need to be secured.

2. **By Antero-posterior Flaps** (*middle of the limb*).—The base of each flap should be equal to one-half the circumference of the limb. The length of the anterior flap should equal that of the diameter of the limb. The posterior flap should be half the length of the anterior. Both are **U**-shaped, and the incisions defining them are commenced just below the future saw-line (Fig. 374, B).

These incisions are so disposed that the brachial artery comes in the posterior flap, and great care must be taken that the division between the flaps is not just over the vessel, which would in such case probably be split in cutting the flaps by transfixion.

An assistant, grasping the limb by the elbow and wrist, flexes the forearm and rotates the extremity as required.

In marking out the anterior flap the arm is so rotated that the flexed forearm is carried towards the surgeon. The incision is commenced on the side of the arm farthest from the operator

(i.e. on the ulnar side of the right arm and the radial side of the left). The knife is carried from above downwards. As it sweeps across the front of the limb to form the tip or bend of the **U** the arm is held straight, and as the blade is carried upwards to complete the other limb of the **U** the arm is so rotated that the forearm is carried away from the surgeon. The posterior flap is marked out with the knife in the same way, the arm being lifted up so that the surgeon can see the posterior surface. These incisions concern the skin only.

The skin having been evenly freed all round, the anterior and posterior flaps are cut by transfixion, the edge of the knife being brought out at the level of the retracted skin. As already said, care must be taken neither to transfix nor to slit the brachial artery.

The bone having been freed up to the saw-line, and the flaps well drawn up, the humerus is divided, care being taken of the musculo-spiral nerve. (*See* page 538).

The objections which have been urged (page 480) against the cutting of the whole flap (muscles and skin) by transfixion apply with especial force to this part. The flaps so cut are cut without precision, and the muscles and skin are divided at the same level.

The rapidity with which the operation may be performed is its sole recommendation.

Hæmorrhage.—Some muscular arteries are divided in the anterior flap. In the posterior flap the brachial, the superior profunda, and the inferior profunda are found severed.

Other Methods.—Among the many other methods of amputating the arm may be mentioned—

(*a*) *Amputation by Lateral Flaps* (Vermale's operation).—A the inner flap retracts the more, it is cut the longer; the flaps are marked out by skin incisions, and the soft parts are then cut by transfixion. There is nothing to recommend this procedure.

(*b*) *Teale's amputation* has been performed in the lower part of the arm. The long flap is placed upon the antero-external aspect of the limb, so that the brachial artery, with the median and ulnar nerves, are found divided in the posterior flap (Fig. 375, A). The operation would be of use in some cases of limited injury.

(*c*) *Malgaigne's operation* consists in cutting a single rounded

flap, usually from the flexor surface—a proceeding "ne durant pas une minute."

(*d*) The method known as "*amputation by antero-posterior flaps with circular division of muscle*" is merely a modification of the circular method. It is little more than the turning back of a divided skin "cuff." The flaps are about three to three and a half inches long, and the cutting of them renders easy the retraction of the integuments—the least simple part of the usual circular operation.

The operation is well suited for very bulky or very muscular limbs.

Comment.—The circular operation is peculiarly well adapted for the lower half of the arm, and is undoubtedly the best procedure for amputation in that situation. The method is not applicable to the upper half of the limb, owing to the freedom of the muscles and their consequent ready retraction. It is here, therefore, that the flap operation proves so serviceable.

A terminal cicatrix would appear to be the one most likely to be free from pressure when an artificial limb has been adjusted.

After the antero-posterior flap operation, the superior retraction of the anterior flap tissues tends in time to make the cicatrix terminal.

The **after-treatment** of these operations calls for no especial comment.

III. AMPUTATION THROUGH THE SURGICAL NECK OF THE HUMERUS

In this operation—the *amputation intradeltoidienne* of the French—the bone is sawn through between the tuberosities of the humerus and the insertions of the pectoralis major and latissimus dorsi. The muscles left attached to the bone in the stump are the subscapularis, the supraspinatus, infraspinatus, and teres minor.

The saw-cut is a little way below the epiphysial line. It is difficult to avoid opening the tubular prolongation of the synovial membrane of the joint which accompanies the biceps tendon in its groove.

The posterior circumflex artery and the circumflex nerve wind round the surgical neck of the humerus.

The *advantages* claimed for the operation are these :—

(*a*) The mortality is said to be less than that attending disarticulation at the shoulder.

(*b*) The resulting stump is of considerable value in attaching an artificial limb, and the scapular muscles do not waste to the same degree as occurs after amputation at the joint.

(*c*) The roundness of the shoulder is to a considerable extent preserved.

The *disadvantages* are the following :—

(*a*) There is risk of opening the shoulder-joint through the synovial diverticula. This, with due aseptic precautions, is of little moment.

(*b*) In young subjects the epiphysis is apt to produce bone after the operation, and to cause a conical stump.

(One of us (J. H.) once performed this operation upon a lad of twelve, and had on two subsequent occasions to remove portions of the shaft of the bone, to rid the patient of a conical stump produced by an active growth of the epiphysis. The stump, however, as it appeared when the lad reached the age of eighteen years, was admirable.)

(*c*) The stump may be rigidly abducted by the muscles attached to the great tuberosity, and become painful and inconvenient.

The operation may be advised in subjects over sixteen, where the case is uncomplicated and there is every prospect of obtaining speedy healing without suppuration.

One of two methods may be selected :—

1. **Guthrie's Operation by the Oval Method.** — The following is Guthrie's description ("Commentaries," 5th ed., 1853, page 120) :—" Amputation of the arm immediately below the tuberosities of the humerus ought to be done in the following manner: The arm being raised from the side, and an assistant having compressed, or being ready to compress, the subclavian artery, the surgeon commences his incision one or two fingers-breadth beneath the acromion process, and carries it to the inside of the arm, below the edge of the pectoral muscle, then under the arm to the outside, where it is to be met by another incision begun at the same spot as the first, below the acromion process.

" The integuments thus divided are to be retracted, and the muscular parts cut through, until the bone is cleared as high as the tuberosities. The artery will be seen at the under part, and should be pulled out by a tenaculum or forceps, and secured as soon as

divided. The bone is best sawn, the surgeon standing on the outside. The nerves should be cut short, and the flaps brought together by sutures.

"There are few or no other vessels to tie, and the cure is completed in the usual time, whilst the rotundity of the shoulder is preserved."

2. **By Single External Flap.**—This operation is thus described by Farabeuf :—

The surgeon marks out a **U**-shaped flap, the width of which is equal to one-half the circumference of the limb, while its length is not less than that of the diameter of the extremity. The base of the flap should be two fingers-breadth below the future saw-line (Fig. 375, B). The internal incision is slightly curved downwards. The incisions at first involve the skin only.

When the integuments have retracted evenly, the external flap is cut by transfixion. The tissues composing it are picked up with the left hand as the knife is passed across the base of the flap as near the surgical neck as possible.

The structures on the inner side of the limb, including the axillary vessels and nerves, are now divided one by one, with the following precautions :—

Especial care should be taken to preserve the tendon of the great pectoral muscle.

When the bone is exposed, the periosteum is divided below the bicipital groove, and is carefully stripped up along that groove by means of an elevator or rugine, taking with it the greater part of the insertion of the pectoralis major.

The synovial sheath of the biceps tendon should not be opened, and that tendon, having been picked up with the finger, should be divided moderately low down. The coraco-brachialis is divided with it. The axillary vessels should be cautiously exposed, and the artery and vein ligatured before they are cut. The nerve cords must be severed high up after they have been individually isolated. The tendons of the latissimus dorsi and teres major are divided close to the bone, although portions of their attached fibres are separated with the periosteum.

CHAPTER V

DISARTICULATION AT THE SHOULDER-JOINT

Anatomical Points.—The roundness and prominence of the point of the shoulder depend upon the development of the deltoid and the position of the upper end of the humerus. The part of the humerus felt beneath the deltoid is not the head, but the tuberosities—the greater tuberosity externally, the lesser in front. A considerable portion of the articular head of the bone can be felt by the fingers placed high up in the axilla when the arm is abducted. The head of the humerus faces very much in the direction of the internal condyle.

The groove between the pectoralis major and deltoid muscles is usually to be made out. In it run the cephalic vein and a large branch of the acromio-thoracic artery. Near the groove and a little below the clavicle the coracoid process may be felt. The process, however, does not actually present in the interval between the two muscles, but is covered by the innermost fibres of the deltoid. The position of the coraco-acromial ligament may be defined, and a knife thrust through the middle of it would strike the biceps tendon and open the shoulder-joint. When the arm hangs at the side with the hand supine, the bicipital groove looks directly forward. In this posture the head of the bone lies entirely to the outer side of a line drawn vertically downwards from the coracoid process.

The skin over the deltoid is comparatively thick and adherent, and retracts little when divided. The skin over the pectoral muscle and over the inner surface of the arm near the axilla is finer, and retracts considerably when severed.

The muscles about the shoulder-joint and their precise attachments should be borne in mind. The capsule of the shoulder-joint is very lax. Its superior part is best exposed by carrying the elbow across the chest ; rotation of the arm outwards brings the anterior part of the capsule to the front, and rotation inwards the posterior part.

The great subacromial bursa intervenes between the capsule and the acromion process.

The main blood supply of the deltoid muscle is derived from the posterior circumflex artery. This artery, with the circumflex nerve, crosses the humerus in a horizontal line which is about a finger's-

breadth above the centre of the vertical axis of the deltoid muscle. The dorsalis scapulæ artery crosses the axillary border of the scapula at a point corresponding to the centre of the vertical axis of the deltoid muscle. The acromio-thoracic artery emerges at the upper border of the pectoralis minor, i.e. at a spot where a line drawn from the third rib (near its cartilage) to the coracoid process crosses the line of the axillary artery.

Air may be drawn into the axillary vein or into some of its larger tributaries if they are wounded and happen to be exposed to the atmosphere—as after sponging—during an inspiration.

Methods of Controlling Hæmorrhage during the Operation.—1. The method of controlling bleeding by means of an elastic band, which is carried across the axilla and brought well up over the point of the shoulder, is strongly to be condemned as useless and dangerous. In such a method the axillary artery is compressed mainly against the humerus. At the moment of the disarticulation the band is apt to slip. It is in the way of the operator, and cannot with any ingenuity be made trustworthy.

2. The compression of the subclavian artery in the neck against the first rib is a less uncertain mode of controlling bleeding.

The vessel is compressed with the fingers, or with an instrument shaped like the handle of a door-key. In stout and muscular subjects, and in cases where the clavicle is lifted up, this method is not applicable. In such circumstances some surgeons have advised that an incision be made over the third part of the subclavian, and the finger or a sterilised compressor introduced through the wound in order that the artery may be more directly reached.

Except in special circumstances, compression of the subclavian is not to be advised. Even with a skilled and careful assistant the method is not absolutely trustworthy. The fingers are apt to slip during the movements of the limb or of the patient, and the assistant who controls the artery is somewhat in the way.

The methods that are the most valuable are these:—

3. The main artery may be compressed in the flap by the fingers of an assistant, who takes hold of the part immediately before the vessel is divided.

This procedure is described in the account of Spence's operation (page 548).

4. The artery may be exposed and ligatured before it is divided, and early in the course of the operation. An account of this method is given in the description of Larrey's disarticulation (page 550), as well as of Spence's (page 548).

Methods of Operating.—Sédillot enumerates twenty different methods of disarticulating at the shoulder-joint, and Lisfranc refers to no fewer than thirty-six procedures under this head. Farabeuf gives illustrations of thirty different amputations at the shoulder. These illustrations form an excellent historical atlas, of which the author modestly says, "Il n'est pas complet, quoique plus que suffisant." Many of these operations have been long abandoned, and are merely curious. Among such may be placed amputations by an axillary flap, as practised by the elder Ledran in 1715, and later by Petit and Garengeot. Others are merely modifications of well-recognised operations, as illustrated by the various forms of external flap and of antero-posterior flaps.

The majority may be classified as modifications of the oval or racket operations.

It is desirable in any disarticulation performed at the shoulder that the acromion process should be left, since it helps to preserve some roundness to the shoulder and to afford a point of support for an artificial limb. It is important also that the axillary vessels be so approached as to be cleanly and certainly cut, and that it be possible to secure them before they are divided.

The glenoid fossa should have as good a covering as is possible, and the methods most frequently practised are those in which the preservation of the whole or greater part of the deltoid muscle is a conspicuous feature.

The wound should be vertical if efficient drainage is to be secured. It is well that the axillary nerves should be divided high up.

The following modes of disarticulating at the shoulder will be described :—

1. The racket method.
    - A. Spence's operation.
    - B. Larrey's operation.
2. The external or deltoid flap.

Instruments.—A stout knife with a blade from four to five inches in length. (If a transfixion operation be performed, an amputating-knife with a blade equal in length to one diameter and a half of the limb will be required.) A scalpel. Ten pressure forceps. Artery and dissecting forceps. An aneurysm-needle, metal retractors, scissors, etc.

Position.—The patient lies close to the edge of the table, with the shoulders raised and the head turned to the opposite side. The upper limb is carried a little from the side.

The surgeon should stand to the outer side of the limb in the case of both the right and the left arms. It is often, however, more convenient to stand to the inner side of the left extremity.

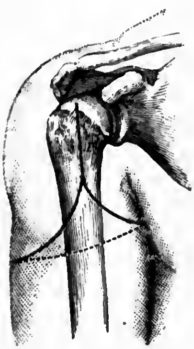

FIG. 376.—DISARTICULATION AT THE SHOULDER BY RACKET INCISION. (*Spence's operation.*)

Three assistants are required. One stands above the operator, by the patient's head, and, leaning over the shoulder, retracts the flaps and compresses the axillary vessels before they are divided. A second assistant, standing below the surgeon, by the patient's hip, holds the limb, and manipulates it as required. The third attends to the sponging. He is placed either facing the surgeon and upon the other side of the table, or by the shoulder.

1. **The Racket Method.** (A) *Spence's Operation.*—The following is Prof. Spence's own account ("Lectures on Surgery," vol. ii., page 662):—

"(1) Supposing the right arm to be the subject of amputation. The arm being slightly abducted, and the head of the humerus rotated outwards if possible, with a broad strong bistoury I begin by cutting down upon the head of the humerus, immediately external to the coracoid process, and carry the incision down, through the clavicular fibres of the deltoid and pectoralis major, till I reach the humeral attachment of the latter muscle, which I divide.

"I then, with a gentle curve, carry the incision across and fairly through the lower fibres of the deltoid towards the posterior border of the axilla, unless the textures be much torn. (The incision so far is carried the whole length directly down to the bone.)

" I next mark out the line of the lower part of the inner section by carrying an incision through the skin and fat only, from the point where my straight incision terminated (i.e. at the lower end of the insertion of the pectoralis major), across the inside of the arm, to meet the incision at the outer part (Fig. 376). This ensures accuracy in the line of union, but is not essential.

" (2) If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out can be easily separated (by the point of the finger, without further use of the knife) from the bone and joint, together with the trunk of the posterior circumflex, which enters its deep surface, and be drawn upwards and backwards so as to expose the head and tuberosities.

" (3) The tendinous insertions of the capsular muscles, the long head of the biceps and the capsule, are next divided by cutting directly on the tuberosities and head of the bone (the humerus being rotated by the assistant as required). The broad subscapular tendon especially, being very fully exposed by the incision, can be much more easily and completely divided than in the double-flap method. By keeping the large outer flap out of the way by a broad copper spatula or the finger of an assistant, and taking care to keep the edge of the knife close to the bone, as in excision, the trunk of the posterior circumflex is protected.*

" Disarticulation is then accomplished, and the limb removed by dividing the remaining soft parts on the axillary aspect."

(4) The final step of the operation is effected as follows :—

The arm, abducted and rotated out, is thrust upwards by an assistant until the head of the bone is projecting well above the glenoid cavity. The surgeon, taking hold of the head thus made prominent, draws it away from the trunk, while he passes his knife behind it so as to cut the posterior part of the capsule and the only remaining tissues—those of the axilla—which connect the arm to the trunk.

* This is a point of much importance, as, unless special care is taken, the posterior circumflex artery is apt to be divided or notched close to its origin. If this accident happens, not only is the nutrition of the deltoid and skin endangered, but considerable trouble may be found in tying the vessel.

An assistant follows the knife with his two thumbs, while he keeps the fingers of both hands spread out over the axillary integument. Just before the main vessels are divided he firmly compresses them, and holds the flap until the several trunks are secured.

All the soft parts on the axillary aspect are divided with one sweep of the knife, which is made to emerge from the skin wound already marked out. The operation is completed by cutting the axillary nerves short, and by uniting the wound so as to form a vertical cicatrix.

In more than one case of amputation at the shoulder-joint I (J. H.) have known troublesome discharge of synovial fluid delay healing of the wound, and it is therefore worth while carefully to dissect out all the synovial membrane before inserting the sutures. There is no real difficulty in doing this, and the result is most satisfactory.

Spence pointed out that the main vessel might be secured by ligature early in the operation, if thought well. "By a few touches of the bistoury," he writes, "the vessel can be exposed, and can then be tied and divided between two ligatures, so as to allow it to retract before dividing the other textures."

In disarticulating, the capsule should be divided transversely by a cut made upon the head of the bone. The three muscles attached to the greater tuberosity are cut while the humerus is being rotated in, the subscapularis while it is being rotated out.

If the humerus be fractured, the upper fragments should be grasped with lion forceps as soon as the deltoid flap has been dissected up, and manipulated as required during the disarticulation.

When the limb is very muscular, Spence advised that the skin and fat should be raised a little from the deltoid along the outer part of the incision, and that when a certain amount of the lower portion of the muscle had been exposed its fibres should be divided by a second incision. This deep incision would be a good deal higher than the one usually made, and so an excess of muscular tissue in the flap would be avoided.

Hæmorrhage.—The main artery is divided between the origins of the posterior circumflex artery and the superior profunda.

On the edges of the vertical incision there may be bleeding from the humeral branch of the acromio-thoracic artery, and in the depths of that incision the anterior circumflex artery will be divided.

There will be bleeding from muscular branches in the deltoid flap, and considerable hæmorrhage should the posterior circumflex artery be unintentionally cut.

(B) *Larrey's Operation.*—This is the method designated by Farabeuf as the best of the many operations for disarticulation at the shoulder.

The skin incisions are those given by Larrey, the mode of dividing the muscles is ascribed to Marcellin Duval, and the method of securing the main artery to Verneuil.

(1) The limb being held a short distance away from the side by an assistant, the surgeon steadies the skin of the shoulder with the left hand while he makes a vertical cut, which is commenced just below and just in front of the prominence of the acromion, and is continued down the arm for four inches.

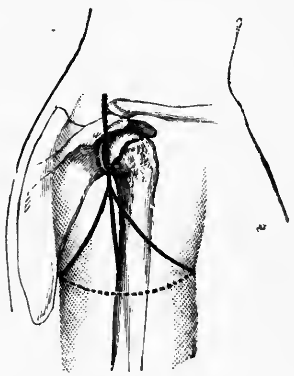

FIG. 377.—DISARTICULATION AT THE SHOULDER-JOINT. (*Larrey's operation.*)

Along this incision the knife is carried through the fibres of the deltoid muscle to the bone. By means of this preliminary wound the shoulder-joint may be explored.

(2) From the *centre* of the vertical incision the oval part of the racket is commenced, and is carried across the front of the arm to pass transversely over the inner side of the limb on a level with the lowest point of the vertical incision. It is finally continued up along the postero-external aspect of the limb to end where it commenced (Fig. 377).

This oval cut at first involves the integuments only. On the right arm it may be made with one sweep of the knife, commencing with the anterior segment of the oval and finishing with the posterior.

On the left extremity the two curved incisions marking out

the oval may be commenced at the lowest point, and be each made by cutting from below upwards.

(3) The anterior part of the wound is now deepened by cutting through the anterior segment of the deltoid. The tendon of the great pectoral muscle is exposed, isolated, and divided close to the bone. The coraco-brachialis and biceps are in the next place isolated and then divided.

To the inner side of these structures the axillary artery is exposed, and is secured below the origin of the posterior circumflex. It may be secured between two ligatures and then divided.

(4) The operator now turns to the posterior part of the oval, and divides the whole of the posterior segment of the deltoid, carrying the knife back to the under part of the axilla. While these deep incisions are being made the arm is rotated as required.

(5) Disarticulation is now effected precisely as in the previous operation, and the remaining axillary tissues which connect the limb with the trunk are severed in the same manner. In this last step of the operation care should be taken that the knife cuts its way out along the skin-wound already marked upon the surface, and that the main vessel is severed only between the ligatures. Any hanging portions of capsule are removed, the nerves are cut short, and the wound is adjusted vertically.

Hæmorrhage.—The main artery is divided as in the previous operation. Some bleeding may occur from the anterior circumflex artery in the region of the bicipital groove. The posterior circumflex artery is very apt to be divided in the posterior segment of the oval incision.

2. **The External or Deltoid Flap.** — This method appears to have been extensively performed in England prior to the introduction of the disarticulation through the racket incision.

If the outer flap be cut by transfixion, the procedure has the merit of being very rapidly performed.

The base of the flap extends from the coracoid process in front to the spine of the scapula at the root of the acromion behind. It is **U**-shaped, and its extremity reaches nearly to the insertion of the muscle. If well shaped, the flap includes practically the whole of the deltoid. At its base it should be represented by the entire thickness of the muscle, while at its margins it should be comparatively thin.

The surgeon should always stand at the outer side of the limb, and almost facing the patient.

(1) The flap is marked out by a skin-incision. In dealing with the right shoulder, the arm should be carried well across the chest, and the knife be entered at the root of the acromion. It is then made to follow the outline of the deltoid, and to end at the coracoid process (Fig. 374, C). As the knife is carried up towards the latter point the arm is withdrawn from the chest and a little abducted.

It is more convenient that the surgeon should manipulate the limb himself with his left hand.

On the left shoulder the process is reversed. The arm is drawn away from the side, and the incision commences at the coracoid, As it approaches the acromion the arm is brought across the chest.

(2) The knife is now carried deeply along the whole length of the incision, and the flap containing the substance of the deltoid muscle is raised. In cutting the flap the knife should be held a little obliquely, in order that the section of the muscle may be comparatively thin at the margins of the flap. The flap is drawn well upwards by an assistant, and the outer surface of the shoulder-joint is thereby exposed.

(3) A transverse incision, involving the skin only, is now made across the inner side of the arm, about two inches below the outlet of the axilla. It joins the great wound in front and behind.

(4) Disarticulation is finally effected in the manner already described, and the operation is completed precisely as in Spence's method. That is to say, after the disarticulation the head of the bone is thrust upwards and outwards, and is grasped by the surgeon, who passes his knife behind it so as to cut the very short internal flap. In effecting this the knife at first passes downward close to the bone, and divides the pectoralis major, latissimus dorsi, and teres major muscles. It is then made to cut its way sharply outwards through the incision already made in the skin.

In this, the last movement of the knife, are divided the coraco-brachialis, biceps, and triceps, with the axillary vessels and nerves.

An assistant follows the knife with his thumbs, and compresses the great vessels, before they are cut, in the manner already detailed.

Hæmorrhage.—In the deltoid flap there will be bleeding from muscular branches only, notably from such as are furnished by the acromio-thoracic artery. The posterior circumflex artery will have been cut. The axillary vessels are divided at the free edge of the inner flap, the artery being cut below the origin of the two circumflex vessels. These arteries will be found severed in the margin of the inner flap, and the posterior of the two will certainly require a ligature.

Comment.—Of the three operations described, the best are those of the racket incision ; and of the two racket operations detailed, the greater value must attach to *Spence's method*.

The advantages claimed for the operation are the following :—

1. The articulation is easily exposed, and an excision can be performed through the vertical cut should the case, on examination, prove to be unsuited for disarticulation.

2. The least possible division of the muscles is made.

3. Disarticulation is easily effected.

4. The posterior circumflex artery is only divided through its terminal branches.

5. The main vessels are easily secured.

6. A very excellent stump results.

In *Larrey's operation* the parts can be divided as neatly and as certainly as in the method just named, and in any case in which Spence's measure may not be applicable this disarticulation may be carried out. A preliminary examination of the joint can be made, and an excision effected if necessary, but the articulation is exposed at some depth, and a considerable section of the muscular tissues is made. Moreover, the posterior circumflex artery is apt to be cut at its origin. A most admirable stump results.

The disarticulation by the *external flap* is simple and easy, and can be carried out with rapidity.

It does not lend itself, however, to a preliminary exploration of the joint. The circumflex artery is divided and the flap is apt to be ill-nourished. The resulting stump is not a good one.

The flap is ill-fitting, and the soft parts do not mould themselves to the glenoid cavity and scapula.

In all these operations it may be claimed that excellent drainage is provided for.

After-treatment of these Operations.—A drainage-tube will be required, as a considerable amount of fluid commonly escapes from the synovial membrane which is left behind.

As noted on page 548, this complication may be avoided by dissecting the membrane out carefully at the time of operation.

Pressure should be applied to the outer flap after the stitches have been introduced, in order that the great cavity left beneath the acromion may be, as far as possible, obliterated.

The patient's thorax should be kept raised, and the body inclined a little towards the injured side.

AMPUTATION OF THE UPPER LIMB TOGETHER WITH THE SCAPULA

This operation, the *amputation interscapulo-thoracique* of French surgeons, has been carried out with considerable success in some few cases of extensive injury of the upper extremity, including gunshot wounds, and in a larger number of examples of malignant tumour involving the region of the axilla and shoulder-blade, the complete removal of which could not be effected without the sacrifice both of the arm and of the scapula. It has been performed also in examples of extensive bone-disease.

A very elaborate account of the operation was published by Paul Berger in 1887, and the monograph includes the histories of 51 cases. The operation appears to have been first performed in 1808 by Ralph Cumming, a surgeon in the British Navy. Mr. Chavasse has appended to an account of a successful operation a list of 44 cases in which the amputation was performed for neoplasms; out of the 44 cases 10 may be counted as cured (*Med.-Chir. Trans.*, vol. lxxiii., 1890). The mortality in the non-traumatic cases was at that date 20 per cent., and in the traumatic cases 30 per cent. The chief risks of the operation are from shock, hæmorrhage, the entrance of air into veins, and wound infection. The mortality of the operation

has diminished in the last ten years, mainly owing to the improvements in obtaining asepsis and in combating shock.

During the Boer War I (F. T.) carried out the operation on the battlefield for gunshot injury. Although the wound was infected the patient made a good recovery.

Mr. Barling (*Clin. Soc. Trans.*, 1898, p. 175) has collected 19 cases operated on since those given in Chavasse's paper. In two of these the operation was done for recurrent scirrhus, in all the remainder for sarcoma of the humerus or shoulder. All these 19 patients recovered. Although interscapulo-thoracic amputation is probably the best measure to adopt in all cases of sarcoma (ossifying or not) of the upper part of the humerus, the prognosis, unfortunately, is very gloomy. In at least 75 per cent. fatal recurrence of the growth has followed within a year after the amputation. In two of Barling's cases, however, the patients were alive four and nine years after the operation.

The result when done for advanced scirrhus of the axilla has been wholly disappointing, and it seems that the operation cannot be justified for this form of malignant growth.

The amputation involves the removal of the upper limb, together with the scapula and the outer two-thirds of the clavicle. No disarticulation is attempted at the shoulder-joint.

Method.—The best method is that of Paul Berger, by two flaps—an antero-inferior or pectoro-axillary flap, and a posterior-superior or cervico-scapular flap.

Instruments.—A strong, stout amputating knife, with a blade from five to six inches in length; a stout scalpel; a periosteal elevator or rugine, curved on the flat; metal retractors, spatulæ, and blunt hooks; a keyhole-saw or a fine chain-saw; bone-forceps, lion forceps, aneurysm-needle, pressure forceps, artery and dissecting forceps, scissors, etc.

Position.—The position of the surgeon varies with each step of the operation, and is described below. Three assistants should be at his service.

Steps of the Operation. — The amputation may be divided into four stages

1. The clavicle is exposed, and is divided at the junction of the middle with the inner third. The middle third of the

bone is excised. The subclavian vessels are exposed, and are secured by double ligatures and divided.

2. The antero-inferior flap is fashioned and the brachial plexus severed.

3. The postero-superior flap is fashioned.

4. The extremity is removed by dividing the tissues still connecting the scapula with the trunk.

The Operation.—*1st Step.*—The patient lies upon the back, close to the edge of the operating-table. The shoulders are raised upon a hard cushion. The arm is by the side or a little separated from it. The surgeon stands to the outer side of the limb, facing the patient. Two assistants are placed one on each side of the surgeon. A third assistant stands on the other side of the body and facing the operator.

The clavicular incision is now made with a stout scalpel. The incision is horizontal, is made along the surface of the bone, commences internally at the outer border of the sterno-mastoid muscle, and ends externally just beyond the acromio-clavicular articulation. The knife divides everything down to the bone. At this stage the sometimes large connecting vein which may pass between the external jugular and cephalic veins may be severed.

The periosteum of the clavicle is divided along the horizontal line corresponding to the original wound, and is also divided vertically or circularly at the inner extremity of the wound. The inner third of the clavicle is not disturbed in any way.

By means of a small rugine or periosteal elevator curved on the flat, the periosteum is separated from the superficial part of the middle portion of the bone, which is now well exposed.

During the use of the elevator an assistant should steady the collar-bone, and render it as prominent as possible.

A large, blunt hook may now be very carefully passed round the inner end of the exposed clavicle, and while an assistant draws the bone forward and steadies it by means of this hook, the surgeon saws it through at about the junction of the middle with the inner third. The section is accomplished by means of a keyhole-saw or by a fine chain-saw, the former being the more convenient.

The blunt hook serves to guide the saw and in some way to protect the deeper parts. During the sawing the middle of the

clavicle should be grasped and further fixed by means of lion forceps. The bone is the more conveniently divided (with the hand-saw) if the blade be directed downwards, outwards, and backwards. A perfectly straight vertical section of the bone is difficult and unnecessary.

The outer fragment of the divided clavicle is now drawn forwards by the lion forceps, the remaining periosteum is separated from its posterior and deep surfaces, and the bared bone is then again sawn through at the outer end of the middle third.

The middle third of the clavicle is thus entirely removed. The exposed subclavius muscle is now isolated, is divided close to the site of the inner section of the bone, and is dissected up so as to expose the great vessels, and turned outwards.

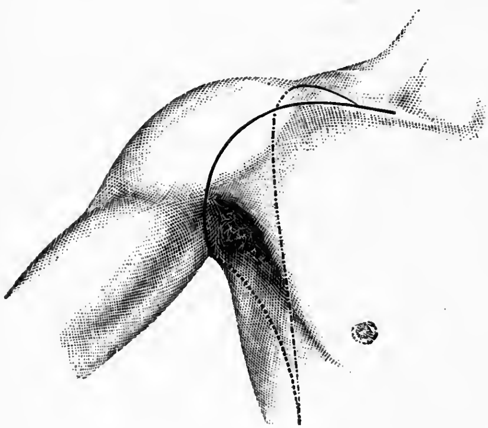

FIG. 378.—INTERSCAPULO-THORACIC AMPUTATION.

Fasciæ of varying thickness will have to be divided before the vessels are reached. A double ligature is passed round both the artery and the vein, and between the ligatures each vessel is divided. The ligature takes place at the lower border of the first rib, and the artery should be exposed and secured before the vein in order that as little blood as possible may be left in the extremity. In some cases ligature of the vein has been left to a later stage, when the anterior flap has been reflected.

2nd Step.—While the patient is still lying on the back, the body is brought as near to the couch as possible, and the shoulder is made to project beyond it.

An assistant draws the upper limb away from the body, and the surgeon stands to the inner side of the limb, i.e. between it and the trunk. The whole of the scapular region should be free of the table, the back resting upon the hard cushion, which is at

the very edge of the table, and the head being drawn to the opposite side.

The assistant moves the limb as required during the cutting of the pectoro-axillary flap.

The incision marking out this flap is commenced at the centre of the clavicular incision, is then curved downwards and outwards, passing just beyond (i.e. to the outside of) the coracoid process, and then runs along the deltoid muscle, parallel to, but to the outer side of, the groove between that muscle and the pectoralis major (Fig. 378). On reaching the point where the anterior wall of the axilla joins the arm, the incision crosses the lower margin of the pectoralis major, and passing transversely across the skin upon the inner or axillary surface of the arm, reaches the lower margin of the tendons of the latissimus dorsi and teres major. At this point the limb is well raised by the assistant, and the wound is completed by carrying the knife downwards and inwards, to stop over the posterior surface of the inferior angle of the scapula. In the last part of the course the knife follows the groove between the vertebral border of the scapula and the muscular mass formed by the teres major and latissimus dorsi.

The incision involves at first only the skin and the subcutaneous tissues.

The surgeon now dissects up the structures of the flap which comprise the soft parts of the pectoral and axillary regions.

The pectoralis major is divided about where it is becoming tendinous, the pectoralis minor is severed close to the coracoid process. An assistant holds back the tissues of the flap, while the surgeon exposes the cords of the brachial plexus, which are then divided at the same level as the main vessels, i.e. close to the first rib.

The shoulder now falls outwards away from the trunk, and the axilla is fully opened up. Any undivided connections of the limb in the axillary region are freed.

The latissimus dorsi is severed in the line of the incision, and serves to form part of the flap.

3rd Step.—The patient lies still in the same position at the extreme edge of the table, but the arm is now carried across the chest by an assistant so as to well expose the scapular

region, and the surgeon takes his place to the outer side of the extremity.

He proceeds to cut the postero-superior flap.

The incision starts at the outer termination of the first or clavicular incision (i.e. at a point just beyond the acromio-clavicular joint), and is carried backwards by the shortest route over the scapular spine to meet the termination of the anterior flap incision, at the inferior angle of the scapula (Fig. 378). The wound concerns the integuments only. The skin is well reflected in the upper part of the incision, so as to lay bare the trapezius muscle. This muscle is divided close to its attachments to the clavicle and scapula, and is entirely severed from its connections with the limb.

4th Step.—Nothing now remains but to sever the connections of the scapula with the trunk.

One assistant holds back the anterior flap, another the posterior. The limb is allowed to hang away from the side, supported by a third assistant, and steadied and directed by the left hand of the operator.

The operator himself may conveniently stand to the inner side of the right arm and the outer side of the left. The superior and vertebral borders of the scapula being made prominent, the following muscles are rapidly divided from above downwards close to the bone: the omo-hyoid, levator anguli scapulæ, rhomboideus minor and major, and the serratus magnus.

The limb is now free. The two teres muscles, the subscapularis, and the supraspinatus and infraspinatus go untouched with the amputated extremity.

Hæmorrhage.—The early ligature of the main vessel renders the bleeding in this formidable operation comparatively slight. In resecting the clavicle and exposing the great vessels no noteworthy bleeding is encountered. In fashioning the anterior flap hæmorrhage may be expected from several muscular arteries and from branches of the acromio-thoracic and long thoracic. The subscapular artery should not be disturbed, although its thoracic branch will be divided.

In fashioning the posterior flap no vessels of any note will be encountered except muscular branches in the trapezius muscle, which are divided as the muscle is cut.

It is during the fourth step of the operation that most hæmorrhage is to be expected. It will come from the vessels descending from the neck or from the suprascapular and the posterior scapular. The former—a small artery the size of the lingual—may be secured close to the omo-hyoid muscle, and as it is about to pass into the supraspinous fossa. The posterior scapular, a somewhat larger vessel, reaches the superior angle of the scapula by following the levator anguli scapulæ muscle. The vessel may be cut and clamped immediately after division of the muscle.

A flagging pulse and other signs of shock should be treated by copious saline infusion or rectal injection, with strychnia given hypodermically.

After-treatment.—The wound, when closed with sutures, forms an oblique line running from above downwards, outwards and backwards. A large pocket is left in the stump, in which inflammatory exudations may readily collect. This pocket should be obliterated by pressure, a matter best accomplished by covering the wound with sponges, over which the pressure of a bandage is brought.

If this be well effected, and if no diseased or damaged tissue have been left behind, a drainage-tube is not required. The patient should be kept well raised up in bed.

There is a special risk of pneumonia after this operation.

CHAPTER VI

AMPUTATION OF THE TOES

As in the majority of cases amputation of the toes is performed for injury, it is not always possible to carry out the precise lines of a formal operation. In not a few instances the " amputation " consists merely in removing a little bone and in trimming a mangled stump.

Anatomical Points.—The two outer toes—and possibly the third toe—are commonly found to be much bent upon themselves, and not lying straight as shown in surgical diagrams. This bending consists in a flexing of the last phalanx or of the last two phalanges upon the first.

The joints of the toes should be defined. The middle of the length of each toe about corresponds to the joint between the first and second phalanges. The line of the metatarso-phalangeal joints follows an easy curve, and is about one inch behind the web of the toes. The head of the first metatarsal bone and the line of its joint can be readily made out by a little manipulation. The heads of the first and of the third metatarsals are in the same transverse line. The head of the second is about 3 mm. in front of this line, and the head of the fourth about 3 mm. behind it ; while the head of the fifth metatarsal is a little more than 1 cm. (nearly half an inch) behind the line.

The last phalanges of the four outer toes are small, squat bones, often nearly square, and an amputation " through " the last phalanges of these toes would in many instances be an absurdity. The shafts of the first and second phalanges are slender and compact, and can be easily divided with a fine saw.

Each phalanx has one epiphysis at its proximal extremity. It is represented by the base of the bone, and joins the shaft between the nineteenth and twenty-first years.

The prominent part of each phalangeal joint—each knuckle—is formed by the head of the proximal bone.

The interphalangeal and metatarso-phalangeal joints are each supported by two lateral ligaments and a glenoid ligament. The former are nearer to the plantar than the dorsal aspect of the joint. The tough, fibrous, glenoid ligament occupies the whole of the plantar aspect of the joint. The head of the proximal bone rests on it ; the

lateral ligaments join it; it is more firmly attached to the base of the distal bone than to the head of the proximal one. Beneath it glides the flexor tendon, the fibrous sheath of which is fixed to it. In the glenoid ligament of the first metatarso-phalangeal joint two sesamoid bones are developed. They are received in grooves on the head of the metatarsal bone, but their more intimate structural connection is with the phalanx. The fibrous sheaths for the flexor tendons have the same arrangement in the foot as in the hand, and the same care should be taken effectually to close them when divided (*See* page 492.)

In dealing with the anterior part of the foot it must be remembered that the foot rests upon the heel, the heads of the metatarsal bones, and the inner margin of the sole. In amputation, therefore, every care should be taken to save as much as possible of the metatarsus, and especially of the first metatarsal bone and the phalanges of the great toe. The same care need not be taken to preserve every possible part of the four outer toes. A sloughing stump has often resulted from too great anxiety to preserve these almost useless digits.

Instruments.—Stout, narrow scalpels, with blades from one inch to two inches in length, and with well-rounded points. A fine key-hole-saw, or minute Butcher's saw. Bone-forceps. Dissecting and artery forceps. Tapes, or strips of aseptic gauze, to retract the toes. Scissors, needles, etc.

Position.—In all these operations upon the toes the patient should lie on the back, and the foot be brought well beyond the end of the couch. The surgeon should sit at the end of the table facing the patient. The assistants stand—facing the surgeon—one on each side of the end of the table. One should fix the limb and hold the toe, while the other attends to the wound.

The operations included in this chapter will be dealt with in the following order:—

I. Amputation of the distal phalanges.
II. Disarticulation at the metatarso-phalangeal joints, and amputation of the toes *en masse* through the metatarsus.

I. AMPUTATION OR DISARTICULATION OF THE DISTAL PHALANGES OF THE TOES

1. **Disarticulation of the Last Phalanx of the Great Toe.** *Large Plantar Flap.*—Hold the toe between the thumb and first two fingers of the left hand—the thumb on the pulp of the toe, the fingers on the nail. Cut the plantar flap as the toe is thus held.

Enter the knife—at right angles to the surface—just over the head of the first phalanx. Cut along the side of the toe to the pulp. This incision should be parallel to the phalanx and nearer to the dorsal than the plantar aspect. Shape the flap as shown (Fig. 379) and return to the same point on the opposite side. The incision should extend down to the bone.

Let the assistant forcibly extend* the last phalanx while the flap is dissected back, it being held by the left hand while so doing. In making this flap the surgeon must keep as close as possible to the bone. When the glenoid ligament is reached, cut it transversely against the base of the last phalanx. The joint is thus opened.

Now let the surgeon forcibly flex the toe and make across the dorsum a transverse cut that at once divides the extensor tendon and opens the joint. Rotate the toe out, and carefully divide the internal lateral ligament. Rotate it in and divide the external band, and the disarticulation is complete. In disarticulating, keep the knife very close to the bone, so as to avoid wounding the plantar digital arteries. Cut the lateral ligaments from without inwards. The cicatrix of the stump will come well on the dorsum.

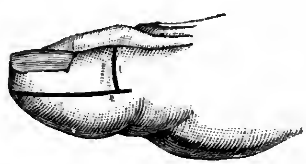

FIG. 379.—DISARTICULATION OF THE LAST PHALANX OF THE GREAT TOE BY A LARGE PLANTAR FLAP.

The long plantar flap should not be cut by transfixion. By so doing the vessels are needlessly damaged and the flap is apt to be scanty. If, on the other hand, too large a flap be cut, a pocket is made in which effusions may collect.

Hæmorrhage.—The two dorsal digital arteries will be cut at the corners of the dorsal incision. They are small, and usually do not need to be secured. If the flap has been well cut, the two plantar digital arteries will not be wounded, but will lie buried in the flap until they anastomose at its free end. They may readily be cut if in dissecting the flap back the knife is not kept close to the bone. They also lie near to the sides of the joint (plantar aspect), and may be easily wounded in careless disarticulation.

In *amputation through the last phalanx of the great toe* the same operation should be employed, the dorsal incision being made nearer the nail. It should be a rule that no more of the great toe should

* To avoid confusion of terms this note may be given: Flexion of a toe = the bending of the toe towards the sole—action of the flexor muscles. Flexion of the foot = the bending of the foot at the ankle so that the toes are brought nearer to the shin—action of extensor muscles.

be removed than is absolutely necessary. An endeavour should be made, when possible, to spare the base of the second phalanx. By so doing the joint is undisturbed, and the insertions of the flexor and extensor tendons are saved.

2. **Amputation** or **Disarticulation of the Distal Phalanges of the Four Outer Toes.**—In operating upon the smaller toes the neighbouring digits should be held aside by the assistant by means of sterilised tapes. It is well not to use too long a scalpel.

The terminal phalanges may be removed by the operation just described.

In *disarticulation of the second phalanx* use the oval or racket incision. Grasp the toe with the left hand and flex it. Enter the knife 1 cm. above the joint and in the median dorsal line. Continue the incision—which should be only skin-deep—along to the middle of the second phalanx. Now curve it down to the plantar margin, cutting to the bone. Forcibly extend the toe and draw the knife transversely across its plantar aspect. Still cut to the bone, and so make a good division of the flexor tendon. Cut up on the opposite side of the toe to meet the straight dorsal incision (Fig. 380, A). In this step cut also to the bone.

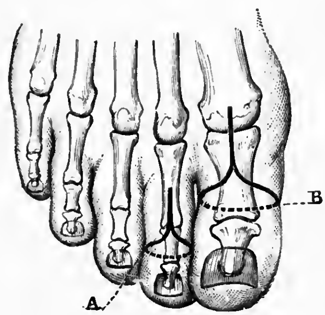

FIG. 380.—A, Disarticulation of the second phalanx of a toe by the racket or oval incision; B, Disarticulation of the great toe by the racket or oval incision.

Now let the assistant forcibly extend the toe; dissect up the lateral and plantar parts of the cut; divide the glenoid ligament transversely against the base of the second phalanx, and thus open the joint. Then divide the lateral ligaments, and nothing will retain the toe but the extensor tendon. Pull upon the toe and divide this tendon as high up as convenient. Close the sheath of the flexor tendon (page 492). The cicatrix will be vertical, i.e. dorso-plantar.

Hæmorrhage.—Two dorsal and two plantar digital arteries are found cut in the lateral edges of the wound. The dorsal will require no attention; the latter may be twisted.

II. DISARTICULATION AT THE METATARSO-PHALANGEAL JOINTS, ETC.

1. **Disarticulation of the Great Toe at the Metatarso-Phalangeal Joint.**—In this operation notice must be taken of the very

large size of the head of the metatarsal bone. Its dimensions are increased by the presence of the sesamoid bones, which should never be removed with the phalanx. It is of considerable importance to the future use of the foot that the head of the metatarsal bone should be preserved, and it will be seen that the chief difficulty of the operation is to provide flap enough to cover the projection. It is important also that the scar should be away from the plantar surface and the line of the sesamoid bones.

The joint can be readily made out by manipulation, especially on the inner aspect of the foot. It is placed about an inch behind the web. The projection of the sesamoids can also very easily be defined.

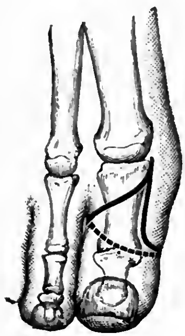

FIG. 381.—DISARTICULATION OF THE GREAT TOE BY INTERNAL PLANTAR FLAP.

The following are the chief methods of operation :—

(1) *By Internal Plantar Flap* (*Farabeuf*).—The surgeon sits to the front and the inner side of the foot. The four surfaces of the digit—dorsal, plantar, internal, and external—should be noted and conceived to be of equal extent. The joint-line is made out, and the toe being grasped with the left hand, the knife is entered over that line and at a point where the dorsal and internal surfaces meet. An incision, 2 cm. in length, is made along the toe, parallel to the extensor tendon and on the line between the two surfaces named. It is then curved downwards over the inner surface to the plantar margin (Fig. 381). The toe is now turned in, and the knife, placed beneath the member, is drawn across the plantar surface to the edge of the web between the toes. The knife is next held above the toe, and the incision completed by a cut to the point of starting, made by the shortest route. The whole of this incision should involve the skin only.

It should now be deepened down to the bone in the same order. In drawing the knife across the plantar surface, extend the toe, so as to cut the flexor tendon high up. Dissect back the flap, keeping close to the bone. In so doing, the assistant should hold the toe and turn it to one or other side as required, while the surgeon uses his left fingers to turn back the soft parts. Separate the tissues about the point of starting; clear the soft parts from the surface of the joint. Forcibly extend the toe, and cut the glenoid ligament transversely close to the base of the phalanx. The joint is thus

opened; the ligament, with the sesamoid bones, remains behind. Divide the lateral ligaments, and finally cut the extensor tendon. Close the fibrous sheath of the flexor tendon (page 492).

Hæmorrhage.—The outer plantar digital artery will be found cut close to the web, the inner vessel at the free end of the inner flap. The dorsal digital vessels will probably not need to be secured.

The flap is adjusted as shown (Fig. 382).

(2) *By Racket* or *Oval Incision.*—The toe is grasped by the left hand. The knife is entered about 1 cm. above the metatarso-phalangeal joint in the dorsal median line. It is continued down to the centre of the first phalanx, and when carried round the toe to form the racket should just avoid the web (Fig. 380, B). The proceeding is identical

FIG. 382.—DISARTICULATION OF THE GREAT TOE BY INTERNAL PLANTAR FLAP: THE RESULTING STUMP. (*Farabeuf.*)

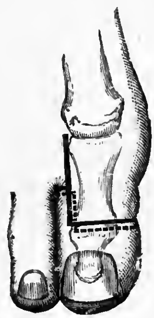

FIG. 383.—DISARTICULATION OF THE GREAT TOE BY RECTANGULAR INTERNAL FLAP.

with that described in disarticulation of the second phalanx (page 563). The joint should be opened from below, through the glenoid ligament.

The fibrous sheath of the flexor tendon may be closed.

In disarticulating, the toe should be manipulated by the assistant, while the surgeon holds back the soft parts with his left fingers. The toe should be turned and twisted to the inner side when dividing the outer lateral ligament, and to the outer side when dividing the inner one. In dissecting back the flap, it is well to keep close to the bone, so as to avoid injury to the digital vessels.

In disarticulating, also, care must be taken to keep close to the phalanx and to cut towards the bone; the soft parts must be well dissected back and the ligaments exposed. If such care be not taken, the plantar digital arteries—which lie close to the joint—will be divided. The cicatrix comes over the head of the bone and is vertical to the sole.

The digital arteries will be found divided at the free margin of the flap on either side.

(3) *By Internal Flap.*—The surgeon grasps the toe with the left hand. The incision is commenced on the dorsal aspect, about 2 mm. below the joint-line and just to the outside of the extensor tendon. It is continued straight down the dorsum of the toe to the level of the interphalangeal joint. From this point a transverse cut is made across the dorsal, internal, and plantar aspects of the toe to the outer border of the flexor tendon (Fig. 383). The incision is now carried back to the web along the outer margin of this tendon. From the web a transverse cut is made across the external and dorsal surfaces to meet the dorsal incision, which it joins above its centre. The whole of this incision should at first involve the skin only.

The internal flap is now dissected up from below upwards. The knife must be kept close to the bone. The extensor tendon is exposed and cut over the joint-line while the toe is being flexed. The joint is thus opened, the lateral ligaments are cut, and a final plantar incision —made while the toe is extended to the utmost—divides the flexor tendon and the glenoid ligament. Close the fibrous sheath of the flexor tendon.

The outer digital vessels are cut close to the web, and the inner in the free edge of the inner flap.

The flaps need not be cut quite so square as is shown.

The cicatrix comes well to the outer side, close to the web, and under cover of the second toe.

Comment.—Of the three operations, the one first described is undoubtedly the best. The cicatrix is out of the line of pressure and is well protected, while the adjustment of the wound is such that excellent drainage is permitted. In the oval operation the cicatrix comes directly over the head of the bone. Good drainage is, however, permitted, and the operation is very easily carried out. It may claim, perhaps, to be the most ready of the three procedures.

The disarticulation by internal flap is not so convenient. The flap is not readily made, and is a little clumsy; the cicatrix, however, is well placed.

In all these disarticulations great care must be taken not to cut the digital arteries, as is so readily done in clearing the bones. The toe has no other source of blood-supply, and if the vessels are cut it is little wonder that the flaps slough or are slow in healing. The artery should run the full length of the flap.

When possible, the base of the first phalanx of the toe should be saved, on account of the important series of muscles to which it

gives attachment (abductor and adductor pollicis, flexor brevis pollicis, and transversus pedis). Although these muscles can no longer act upon the toe, they are of value in maintaining the strength of the sole.

The skin in this region is often much thickened, and is consequently unyielding, and in adjusting flaps it is important to take care that too much strain does not come upon the sutures.

2. **Disarticulation of the Outer Toes at the Metatarso-Phalangeal Joints.**—The best operation is that by the *oval* or *racket incision* already described (pages 563, 565). Care must be taken that the toes on either side of the one to be removed are held apart with sterilised tapes or bands of gauze by the assistant.

In disarticulating the little toe, the *dorso-external flap* advised by Farabeuf will be certainly found to give the most convenient stump. Its application, however, in practice must be exceedingly limited.

FIG. 384.—DISARTICULATION OF THE LITTLE TOE BY DORSO-EXTERNAL FLAP; THE RESULTING STUMP. (*Farabeuf.*)

The knife is entered on the dorsum, just below the joint, and to the inner side of the extensor tendon. The incision follows the inner edge of the tendon for the whole length of the first phalanx. It is then inclined outwards across the outer aspect of the toe, and carried back to the level of the web. By this means a **U**-shaped flap, with unequal limbs, is formed from the structures on the dorsal and external surfaces. The two extremities of the **U** are now united by a cut which crosses the plantar and internal aspects of the toe, and joins the dorsal incision by the shortest route.

The cicatrix that results from this amputation is removed from pressure. It lies well to the inner side, and is protected by the fourth toe (Fig. 384). The importance of closing the tendon-sheaths has been discussed on page 561.

3. **Disarticulation of the Toes en masse at the Metatarso-Phalangeal Joints, and Amputation through all the Metatarsal Bones.**—The necessity for either of these two operations can very rarely arise, and the method employed must necessarily vary with the amount of tissue available. We therefore omit any description of them. The important points are:

(1) Make the chief flap from the sole, and see that it includes the plantar blood-vessels intact almost to the end of the flap, i.e. that the latter includes every tissue down to the bone.

(2) Make special allowance for the thickness of the shaft and head of the great-toe metatarsal as compared with the other bones, and, if necessary, shape a small flap on the internal aspect of the foot to cover it.

(3) Be sure there is no tension on the flaps when brought together. If there is, do not hesitate to reflect them somewhat, and to divide the bones higher up. A tight scar in this position would be unbearable.

AFTER-TREATMENT OF AMPUTATIONS OF THE TOES

It must be confessed that the wounds of these operations do not always heal so kindly as might be expected, and often compare unfavourably with like wounds in the hand. In a few cases this may be due to the fact that the operation is an imperfect one—a mere trimming of a mangled part—and is the outcome of a desire to remove as little tissue as possible.

The less easy circulation of the part, and the circumstance that the wound is less conveniently placed for drainage, may serve in other cases to explain the tardier healing when compared with operation wounds of the fingers.

There is little doubt, however, that the chief reason lies in imperfect disinfection of the skin before operating. The clefts between the toes are unrivalled breeding-grounds for bacteria. Before an amputation in this region the most sedulous care should be paid to repeated disinfection with alcoholic solution of biniodide of mercury or of carbolic acid. If the aseptic precautions be thorough, the wound will probably heal as well here as in any other part of the body.

No drainage-tube is required in these minor operations, as a rule. The leg should be a little raised upon a pillow, and the patient should lie so that the foot can rest upon one or other side. When the patient lies flat on the back, the toes point upwards, drainage is rendered almost impossible, and every facility is given for the gravitation of the effusions of the wound into the depths of the foot. If the flaps have been carelessly cut, if the tendon-sheaths have been left open, if the wound is not perfectly aseptic, and if the foot is so placed that proper drainage is impossible, it is no matter for wonder that the stump fails to do well, and that deep-seated suppuration is detected in the foot.

As the skin of plantar flaps is usually thick and stiff, sutures should be so applied as to retain a good hold of the parts. They should not be removed too soon, as the flap may give way. Silkworm-gut sutures may often be left in for ten or even fourteen days.

CHAPTER VII

PARTIAL AMPUTATION OF THE FOOT

I. AMPUTATIONS THROUGH THE TARSO-METATARSAL JOINTS

THESE operations consist in the removal of single toes, with their respective metatarsal bones, and in the removal of the whole of the metatarsus by Lisfranc's and Hey's operations.

The amputation of a single toe, together with the whole of its metatarsal bone, is an operation of little practical utility. It may possibly be of service in some very limited and rare forms of disease, and it is conceivable that it may be called for in some exceptional accidents. The great toe and the little toe are the ones most likely to afford material for this operation. The elaborate procedures described by French authors for the disarticulation of the second or the third or the fourth toe, together with its metatarsal bone, are purely dead-house operations

Anatomical Points.—There may be said to be three separate joints between the tarsus and metatarsus. First, the joint between the internal cuneiform bone and the first metatarsal; second, that between the three cuneiforms and the second and third metatarsals; and third, the joint between the cuboid and the fourth and fifth metatarsal bones. Looked at as a whole, the union of the tarsus with the metatarsus is very uneven, owing to the backward projection of the second, fourth, and fifth bones behind the line of the third, and the forward position of the first, which articulates with the inner cuneiform nearly half an inch in advance of the second and about a quarter of an inch in front of the third metatarsal bone, where they articulate with the middle and outer cuneiforms respectively. The second metatarsal is let back into a space between the three cuneiform bones. The three outer metatarsals are placed pretty evenly in a line having a gentle curve, with its convexity towards the phalanges (Fig. 385).

The Inner Tarso-Metatarsal Joint.—The internal cuneiform bone presents a large, nearly flat, kidney-shaped, articular surface, inclined

a little inwards. Its long axis is vertical, and measures one inch. Its breadth is half an inch (Fig. 386). The facet on the first metatarsal is of the same general shape. This bone is connected with the inner cuneiform by a complete capsule, the fibres of which are very thick on the under and inner aspects. Those on the outer side pass from behind forwards in the interval between the interosseous ligaments which connect these two bones with the second metatarsal. The plantar ligament is by far the strongest.

The Middle Tarso-Metatarsal Joint.—The facets on the middle and external cuneiforms are flat and triangular, with their bases at the dorsum. Each measures about three-quarters of an inch vertically, and the width of its base is about half an inch (Fig. 386).

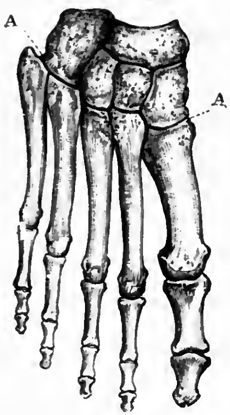

FIG. 385.—BONES OF FOOT. A A, Line of Lisfranc's amputation.

Lateral facets on the inner and outer cuneiform bones articulate with like facets on the sides of the base of the second metatarsal. The posterior facets on the second and third metatarsals correspond in size and shape with those on the two middle cuneiforms.

The ligaments of the joints are the following: Dorsal: between the bases of the two metatarsals and the three cuneiform bones. Plantar: a strong ligament between the inner cuneiform and the second and third metatarsals, and slender ligaments between the middle cuneiform and the second metatarsal, and the outer cuneiform and the third bone. Interosseous: the middle portion of the tarso-metatarsal joint is shut off from the inner portion by a very strong interosseous ligament (the ligament of Lisfranc), which extends between the outer surface of the first cuneiform and the inner surface of the base of the second metatarsal. A second band runs from the external cuneiform to the third and fourth metatarsals, and shuts in the joint on its outer side.

The Cubo-Metatarsal Joint.—The cuboid looks forwards and outwards, and presents two unequal facets, which articulate with like facets on the fourth and fifth metatarsal bones (Fig. 386). Dorsal and plantar ligaments pass between the cuboid and the two bones, while the interosseous ligament just named shuts off the joint on its inner side.

The *synovial membrane* of the inner articulation is single, and separated from all the other tarso-metatarsal joints. That of the

middle articulation is an extension forwards from the synovial membrane of the scapho-cuneiform and outer cuneiform articulations, while the synovial membrane of the cubo-metatarsal joint is special to that articulation and to the joint between the bases of the fourth and fifth metatarsal bones.

Each metatarsal bone has one *epiphysis*, which is placed at the distal extremity of the four outer bones (and forms the head), and at the proximal end of the metatarsal of the great toe, of which it forms the base. The epiphyses join the shafts between eighteen and twenty.

The following *attachments of tendons* may be noted: To the base of the first metatarsal bone the peroneus longus and part of the tibialis anticus; to the base of the fifth metatarsal the peroneus brevis and peroneus tertius.

The communicating branch of the dorsalis pedis artery passes between the bases of the first and second metatarsal bones. The plantar arch crosses the joint between the fourth and fifth metatarsals obliquely, and runs over the bases of the second and third metatarsals at some little distance from the line of the tarso-metatarsal joints.

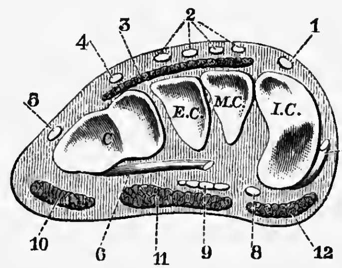

FIG. 386.—TRANSVERSE SECTION OF THE FOOT AT THE TARSO-METATARSAL LINE OF JOINTS.

C, Cuboid; I.C., M.C., E.C., the three cuneiform bones; 1, Ext. prop. pollicis; 2, Ext. long. digit.; 3, Ext. brevis digit.; 4, Peron. tertius; 5, Peron. brevis; 6, Peron. longus; 7, Tibialis ant.; 8, Flex. long. poll.; 9, Flex. long. digit.; 10, Abduct. min. digit.; 11, Flex. brev. digit.; 12, Abduct. hallucis.

Instruments.—A stout knife with a blade three inches long. (For the flap operation upon the great toe a more slender knife, with a blade of about three and a half inches in length.) Narrow metal retractors. Lion forceps (in the event of the part being crushed). Dissecting, pressure, and artery forceps.

Position.—The same as for previous amputations. (*See* page 561.)

I. DISARTICULATION OF A TOE, TOGETHER WITH ITS METATARSAL BONE

(1) **Disarticulation of the Great Toe, together with its Metatarsal Bone.** *By Oval* or *Racket Incision.*—Having defined the metatarso-tarsal joint, grasp the toe with the left hand, and enter the knife at the inner border of the foot, just below the line of the joint. Carry the incision outwards, parallel

to the articulation line, until the centre of the dorsal aspect of the metatarsal bone is reached (Fig. 396, A). Now continue the cut straight down towards the nail, along the median line of the dorsum of the bone. This incision will lie to the inner side of the extensor proprius pollicis tendon. On reaching the centre of the metatarsal bone, incline the incision to the web, then round the outer side of the root of the toe (the phalanx being turned out), and so on to the plantar aspect. Let the knife cross the plantar surface transversely in the groove that separates the toe from the sole. Finally, curve the incision round the outer aspect of the toe to reach the dorsal wound at the centre of the metatarsal bone. The incision involves the skin only.

Now deepen the dorsal cut. Divide the tendons of the extensor proprius and extensor brevis close to the metatarso-tarsal joint. Separate the soft parts from the inner and outer sides of the bone, keeping close to it, and cutting from the tarsus towards the toe. While effecting this separation the assistant turns the toe to one or other side, and the surgeon uses his left fingers to draw away the soft parts. The assistant now partly extends the toe, and, the flexor tendon having been cut, the soft parts are dissected off from the plantar aspect of the bone. The bone should be bared back to the joint. The sesamoid bones are left behind.

Care must be taken not to wound the communicating branch of the dorsalis pedis artery which runs between the two toes.

The next step is to open the joint on the dorsal aspect, and as far as possible on the outer and inner sides. The surgeon now once more grasps the toe and divides the plantar and remaining ligaments. Last of all, the tendons of the peroneus longus and tibialis anticus are cut, and the toe with its metatarsal bone is free.

Cut the flexor tendon short, and close its sheath (page 492). If the transverse cut at the commencement of the incision be not employed, the wound must start over the cuneiform bone.

Hæmorrhage.—The dorsal digital branches (of the first interosseous artery) to the sides of the toe are divided in the dorsal incision. The inner one will probably need no attention. In the plantar aspect of the wound are divided the termination of

the internal plantar artery, the first plantar digital artery, and the internal digital branch to the great toe. There is great risk of wounding the communicating branch of the dorsalis pedis in the gap between the first and second toes.

(2) **Disarticulation of the Little Toe, together with its Metatarsal Bone, by the Oval** or **Racket Incision.**—The toe being grasped by the left hand, the knife is entered at the outer margin of the foot about 1 cm. behind the tuberosity of the fifth metatarsal bone. An oblique cut—parallel with the cubo-metatarsal joint—is made (Fig. 395, A), and a median dorsal incision is carried thence to the neck of the metatarsal bone. Here the oval is made just as in the disarticulation of the great toe (page 571). The subsequent steps of the operation are practically identical with those already described.

The outer tendon of the extensor longus digitorum lies to the inner side of the wound, and is divided at the highest point of the dorsal incision. At this point also some portion of the fleshy part of the extensor brevis will be exposed.

When the outer and inner sides of the bone have been cleared of soft parts, the tendons of the peroneus tertius and peroneus brevis are cut, the joint between the cuboid and fifth metatarsal and also that between the bases of the fourth and fifth bones are opened from the dorsum. The plantar surface of the bone is then cleared, and the disarticulation is completed as in the case of the great toe.

To the base of the bone strong processes from the plantar fascia are attached, and require division. It should be remembered that a double articulation is opened in this operation (page 570).

Hæmorrhage.—In the dorsal incision the dorsal digital arteries of the toe are divided, while the plantar digital vessels are found cut on the plantar aspect of the wound. Special care should be taken not to wound the plantar arch in disarticulating the base of the metatarsal. In a case in which this accident happened, not only was the bleeding very difficult to check, but secondary hæmorrhage occurred a few days later.

Any one of *the other metatarsal bones* may be removed, with its corresponding toe, by the oval incision. The outer two bones may in like manner be removed together by the oval operation,

the *queue* of the oval running along the interosseous space between the two bones.

As already stated, these operations are of little practical value. (For the after-treatment, *see* page 568.)

2. LISFRANC'S OPERATION

A disarticulation of the anterior part of the foot at the tarso-metatarsal line, useful in limited cases of bone disease, of frost-bite, or of gangrene, and in some examples of perforating ulcer of the foot. (For the anatomy of the line of joints, *see* page 569, and Fig. 385.)

Instruments.—A strong, stout, narrow knife, about four or five inches long in the blade; a scalpel; a saw, in the event of the joints being ankylosed; a narrow metal spatula; several pairs of Wells' dissecting forceps; lion forceps if the toes be crushed.

Position.—The patient lies on the back. The foot is drawn well beyond the end of the table, and is raised upon a support until on a level with the surgeon's neck. The operator may stand to cut the dorsal flap, but should sit at the end of the table facing the patient to cut the sole flap and complete the disarticulation. The assistants stand one on each side of the end of the table.

Operation (*Right Foot*). (1) *The Dorsal Flap.*—Grasp the extended foot with the left hand, so that the thumb is on the base of the fifth metatarsal bone and the forefinger on that of the first, while the palm of the hand faces the sole. The skin on the dorsum is stretched, and the knife is held in the free hand, with the forefinger on the back of the blade. In this position the dorsal flap is cut. The incision commences at the outer margin of the foot, just behind the tubercle of the fifth metatarsal bone (Fig. 387). For about an inch it follows the outer border of the bone. It then sweeps across the dorsum parallel to the line of the tarso-metatarsal joints and about half an inch in front of it. The cut is curved towards the toes, and reaches the plantar aspect of the inner border of the foot about half an inch in front of the tarsal joint of the great toe. It finally follows the inner margin of the foot, and ends three-fourths of an inch behind the said joint.

The assistant now holds the foot fixed in the extended position while the surgeon uses his left fingers to dissect back the dorsal flap. The dissection at first includes the skin only; but when the integument has been retracted about one-fourth of an inch, the extensor tendons are divided. The flap contains, therefore, all the soft parts down to the bones. It is important to expose the metatarsus well, and to carry the flap back far enough to expose the tarso-metatarsal joint-line. (*See* the Comment upon the operation, page 578.)

(2) *The Plantar Flap.*—The plantar flap is now cut. The surgeon flexes the foot with the left hand, his thumb being along the lines of the toes and his fingers on the dorsum. The knife is introduced at right angles to the surface of the now well-exposed sole. The incision, commencing on the outer side, follows the plantar edge of the fifth metatarsal for a short distance, and then sweeps obliquely across the sole to the neck of the fourth metatarsal. It now traverses the sole just behind the line of the heads of the metatarsus, and finally follows the plantar edge of the metatarsal bone of the great toe to join the extremity of the dorsal incision. The plantar flap is thus convex forwards, and the inner segment is longer than the outer (Figs. 387 and 399, A).

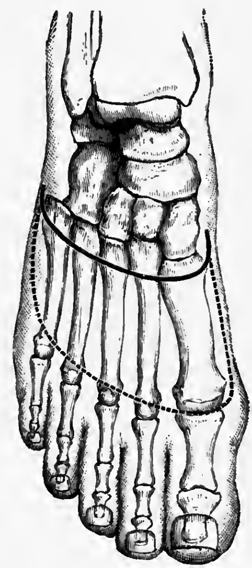

FIG. 387.—LISFRANC'S AMPUTATION.

The incision at first involves the skin and the subcutaneous tissues only. The assistant now grasps the toes and keeps them fully extended while the surgeon dissects back the flap. This should include the subcutaneous structures only until the hollow behind the heads of the metatarsal bones is reached. When this hollow is exposed, the tightly-stretched flexor tendons are divided by a vigorous transverse cut. The rest of the flap includes all the soft parts down to the bones. These are dissected up by short transverse cuts with the knife while the operator pulls back the flap. The separation is carried back until the line of the tarso-metatarsal articulations is reached. The exposure of the peroneus longus

tendon will indicate when this line is reached. The tendon should for the present be left uncut.

(3) *The Disarticulation.*—Return to the dorsum. Grasp the foot with the left hand and extend it fully. Let an assistant hold back the dorsal flap with one hand while by means of a metal spatula he retracts and protects the plantar flap with the other. Enter the knife just behind the tubercle of the fifth metatarsal bone, and, cutting obliquely forwards and inwards, open the tarsal joints of the three outer metatarsal bones. In this manœuvre the tendons of the peronei brevis and tertius are divided. Now turn to the inner side of the foot, and open the joint between the first metatarsal and the inner cuneiform,

FIG. 388.—LISFRANC'S AMPUTATION: DIVISION OF THE INTEROSSEOUS LIGAMENT BETWEEN THE INTERNAL CUNEIFORM AND SECOND METATARSAL BONES.

The point of the knife is insinuated beneath the ligament, and the blade then raised as the front of the foot is depressed with the left hand.

cutting at the same time the tibialis anticus expansion. In the next place, open the joint between the second metatarsal and the middle cuneiform on its dorsal aspect. The complete separation of the metatarsal bone is difficult, and is thus effected: Hold the knife like a trocar and—keeping it nearly parallel with the dorsum of the foot—thrust the point in deeply between the bases of the first and second metatarsal bones (Fig. 388) until it is arrested by bone. The edge is turned towards the ankle. Now grasp the knife in the hand like a dagger, and elevate the handle until it is perpendicular to the dorsum of the foot, at the same time cutting in the direction of the external malleolus (Fig. 389). By this manœuvre (the *coup de maître*) the strong ligament of Lisfranc (page 570) is severed.

Divide any remaining ligaments, especially those on the

plantar aspect of the joints, and finally the metatarsus is left attached only by means of the peroneus longus tendon. Draw this tendon out, and cut it at the outer angle of the incision, and the parts to be removed are free.

Left Foot.—Commence the dorsal and plantar incisions on the inner side of the foot. In disarticulating, open first the joint between the metatarsal bone of the great toe and the inner cuneiform, then open the tarsal joints of the three outer metatarsals, and finally disarticulate the second metatarsal.

Hæmorrhage.—In the dorsal flap are divided the dorsal interosseous arteries (four), opposite to the interosseous spaces, and the plantar branch of the dorsalis pedis as it dips down between

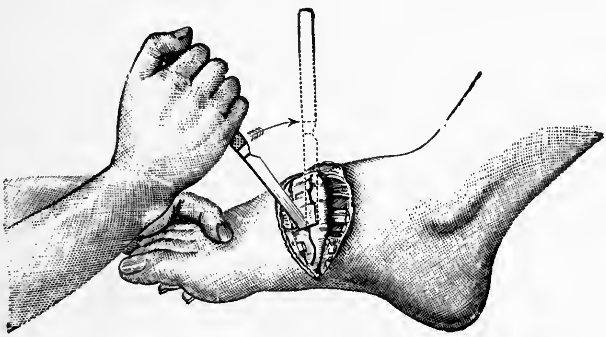

FIG. 389.—THE COUP DE MAÎTRE IN LISFRANC'S AMPUTATION: SECOND STEP. (*After Guérin.*)

the bases of the first two metatarsal bones. In the plantar flap are divided the plantar digital branches of the external plantar, and probably that vessel itself, near the base of the second metatarsal. The terminal part of the internal plantar artery is also divided.

Comment.—The dorsal flap having been made, the disarticulation may be at once proceeded with, and the operation completed by cutting the plantar flap from within outwards—i.e. practically by transfixion. Or, the disarticulation having been effected from the dorsum, the plantar flap may be subsequently cut in the manner already described. On the other hand, the operation may be commenced by cutting the plantar flap, and then be completed by the making of the dorsal flap and disarticulation.

These various modifications, together with the procedure described at length, are all known generally by the term "Lisfranc's operation."

The stump resulting from this amputation is well formed and useful.

The following points may be observed in the performance of the operation :—

It is a common fault to make the dorsal flap too small, and to limit it strictly to the dorsum. This flap should include not only the dorsal structures, but also the greater part of those of the outer and inner margins of the foot. The relative sizes of the two flaps may be estimated by noting the measurements of half the circumference of the foot at the amputation-line. An unduly large plantar flap forms an unwieldy pocket. If the dorsal incision be carried too far back, the joint between the scaphoid and cuneiform bones may be opened by mistake on the inner margin of the foot.

In dissecting back the dorsal flap the knife should be kept close to the bones, and care must be taken not to damage the interosseous vessels that run in the flap. In this flap portions of the interossei muscles will be found, and especially some fibres of the first dorsal interosseous. The line of the articulations must be well exposed.

In disarticulating, care must be taken not to damage the plantar flap. During the separation of the second metatarsal from the tarsus, we have seen the foot so vigorously extended that the bone has been fractured through its base, and much difficulty has been experienced in removing the fragment thus left behind.

3. HEY'S OPERATION

This operation resembles Lisfranc's procedure in all essential points, and differs only in this : the four outer metatarsal bones are disarticulated from the tarsus, and the projecting end of the internal cuneiform bone is sawn through, carrying the first metatarsal bone with it. As "Hey's operation" has been variously described, we give here the original description :—

"In the year 1799 I had the opportunity of repeating this operation" (resection of the front of the foot), "and found it to answer

perfectly my expectations. I made a mark across the upper part of the foot, to point out as exactly as I could the place where the metatarsal bones were joined to those of the tarsus. About half an inch nearer the toes I made a transverse incision through the integuments and muscles covering the metatarsal bones. From each extremity of this wound I made an incision (along the inner and outer sides of the foot) to the toes. I removed all the toes at their junction with the metatarsal bones, and then separated the integuments and muscles forming the sole of the foot from the inferior part of the metatarsal bones. . . . I then separated with the scalpel the four smaller metatarsal bones at their junction with the tarsus, which was easily effected, as the joints lie in a straight line across the foot. The projecting part of the first cuneiform bone, which supports the great toe, I was obliged to divide with a saw."

Hey himself appears to have been a little indefinite about the procedure that bears his name, for in one of the instances he dissected out all the metatarsal bones, and in another he drew the saw across the bases of those bones.

II. Amputation Through the Medio-tarsal Joint (Chopart's Operation)

This consists of a disarticulation of the foot at the medio-tarsal joint. The procedure that at the present day is known by this name differs somewhat in detail from the operation as originally described by Chopart.

Anatomical Points.—The medio-tarsal joint consists of two articulations—the calcaneo-cuboid on the outer side, and the astragalo-scaphoid on the inner. These two joints have distinct synovial membranes. They lie nearly in a transverse line, but the astragalo-scaphoid joint is more convex anteriorly, and is a little in advance of the companion articulation. The first-named articulation forms a ball-and-socket joint, the convex head of the astragalus being secured in the concave facet of the scaphoid (Fig. 390).

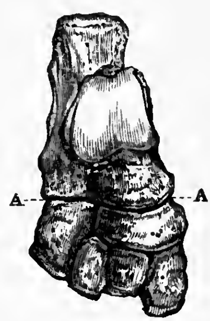

FIG. 390.—BONES OF THE FOOT.
A A, Line of Chopart's amputation.

The greatest vertical measurement of the articulation is one inch, while its greatest transverse measurement is about the same. The

following ligaments support the joint: (1) The astragalo-scaphoid, a thin dorsal ligament; (2) the inferior calcaneo-scaphoid, a dense, thick fibrous plate, that lies just under the joint; (3) the external calcaneo-scaphoid. This band lies in the hollow between the two joints of the mediotarsal line. It starts from the os calcis, and blends above and below with the two ligaments already named. It is called by the French the **Y** ligament, "la clef de l'articulation de Chopart." The synovial membrane of this joint is common also to the anterior astragalo-calcaneal articulation.

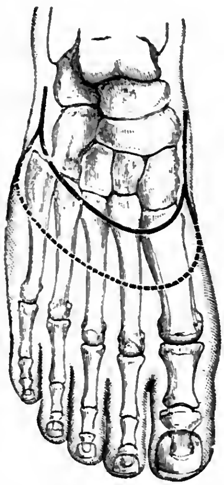

FIG. 391. — CHOPART'S AMPUTATION.

The calcaneo-cuboid joint presents a concavo-convex surface, the concavity inclining from above downwards and inwards. It measures about three-quarters of an inch vertically and one inch transversely. It is supported by the following ligaments:—(1) The internal calcaneo-cuboid, a strong band; (2) the dorsal calcaneo-cuboid, a wider ligament; and (3) and (4), the well-known long and short plantar ligaments. The synovial membrane is peculiar to the joint. This articulation lies on a line midway between the tip of the external malleolus and the tuberosity of the fifth metatarsal bone. The companion joint will be found just behind the tuberosity of the scaphoid—a conspicuous landmark.

Instruments and **Position.**—The same as for Lisfranc's operation. The surgeon should sit to cut the plantar flap, but will find it more convenient to stand while cutting the dorsal flap and while disarticulating.

Operation.—In its main points the procedure is identical with Lisfranc's amputation.

1. *The dorsal flap.*—The incision commences at a point midway between the tip of the outer malleolus and the tuberosity of the fifth metatarsal on the outer side, and at a point just behind the tuberosity of the scaphoid on the inner side. The cut follows on either side the margin of the foot for a little distance, and is then so curved over the dorsum as to cross the bases of the metatarsal bones (Fig. 391).

2. *The plantar flap* extends between the two points first

named. It follows in the main the lines of Lisfranc's flap, and has the same shape. It is so carried over the sole as to cross the middle of the metatarsus (Figs. 391 and 399, B). The flexor tendons are divided as soon as a little skin has been retracted. Both flaps contain all the soft parts down to the bones. The mediotarsal joint-line should be well exposed.

3. *The Disarticulation.*—In disarticulating, the foot may be conveniently held in the position of talipes varus, and be well extended. Care must be taken to open the right joints. It is easy to open the scapho-cuneiform joints in the place of the astragalo-scaphoid, and actually to leave the scaphoid behind.

FIG. 392.—ANATOMY OF THE STUMP AFTER CHOPART'S AMPUTATION. (*Farabeuf.*)

The tendons that are especially to be noted in cutting the deeper parts are the three peronei and the two tibials.

Hæmorrhage.—In the dorsal flap, the dorsalis pedis artery is cut as it dips down between the first and second metatarsal bones. The metatarsal and tarsal branches of that vessel are also divided. The two saphenous veins come in this flap.

At the anterior part of the inner segment of the plantar flap the internal plantar artery is divided, and near the base of the second metatarsal bone the end of the external plantar. In the outer part of the flap are the digital branches of the latter vessel.

Comment.—The value of this operation is open to serious question, and in many points it does not compare favourably with Syme's amputation. It is not adapted for cases of bone disease as a rule. The stump may appear an excellent one immediately after the operation. In process of time, however, it will be found that the whole of the os calcis—and not the tuberosities merely—is brought in contact with the ground, and that the somewhat sharp-edged anterior part of the bone is not well suited to bear pressure.

In some cases the stump has a tendency to turn over into what would be the varus position, and the patient walks upon the outer border of the under surface of the os calcis. In other instances—and these are not uncommon—the heel is drawn

up by the action of the tèndo Achillis, the head of the os calcis is tilted downwards, and upon this point of bone the patient walks (Fig. 392). A stump so deformed will be painful, and will probably become too tender to bear the weight of the body; or the cicatrix, being exposed to pressure, may break down. Attempts have been made to prevent this mal-position by attaching the anterior tendons, including especially the tibialis anticus, by stout sutures to the tissues of the sole-flap.

It has been further recommended that a wedge-shaped pad be worn in the boot, so placed as to resist the turning down of the head of the os calcis. Finally, the tendo Achillis has been divided. This tenotomy, while it has weakened the foot greatly, has not always sufficed for the permanent cure of the deformity. (*See* Tripier's Operation, page 600).

The planning of the flaps may be varied. If the dorsal flap be curtailed, the plantar flap must be increased in length. Some surgeons, having made the dorsal flap, and effected the disarticulation, cut the plantar flap by transfixion. Such a flap, however, is apt to be ill-shaped and thin, and the plantar arteries will be probably divided unnecessarily high.

It has been advised to leave the scaphoid bone when sound, and so to retain the attachment of the tibialis posticus. To effect this end the flaps must be cut longer on the inner side. It has not been shown that this modification is of special value. (For the after-treatment, *see* page 589.)

III. Subastragaloid Disarticulation

This operation consists of a disarticulation at the astragalo-scaphoid and astragalo-calcaneal joints. The astragalus is the only bone of the foot that is left behind, and forms the summit of the stump.

Anatomical Points.—The astragalo-scaphoid joint has been described (page 579). (*See also* Fig. 390.)

The os calcis articulates with the astragalus by a double joint; the anterior communicates with the mediotarsal articulation; the posterior is separate and complete in itself. The two bones each present two articular facets of unequal size, separated by a deep groove, in which is lodged the interosseous ligament. This groove and liga-

ment divide the anterior from the posterior joint. In front of the inner end of the groove the prominent process—the sustentaculum tali—projects inwardly. The posterior facet is the larger, is convex on the os calcis, concave on the astragalus, and is about one inch and a half in length and three-quarters of an inch in width. The anterior facet is narrower, smaller, and more internal. It is concave on the os calcis, and runs on to the upper surface of the sustentaculum tali, while it is convex on the astragalus.

The under surface of the astragalus, as seen after the disarticulation, is, speaking generally, flat, and forms an even surface for the end of the stump. The groove between the facet runs obliquely from within forwards and outwards.

The following are the ligaments between the os calcis and astragalus. The main connection is effected by the very massive interosseous ligament, which occupies the whole length of the groove. On the outer side are the membranous external calcaneo-astragaloid and external calcaneo-scaphoid ligaments, and a part of the external lateral ligament of the ankle. Behind is the posterior calcaneo-astragaloid ligament, and on the inner side the internal ligament of that name, together with part of the internal lateral ligament of the ankle.

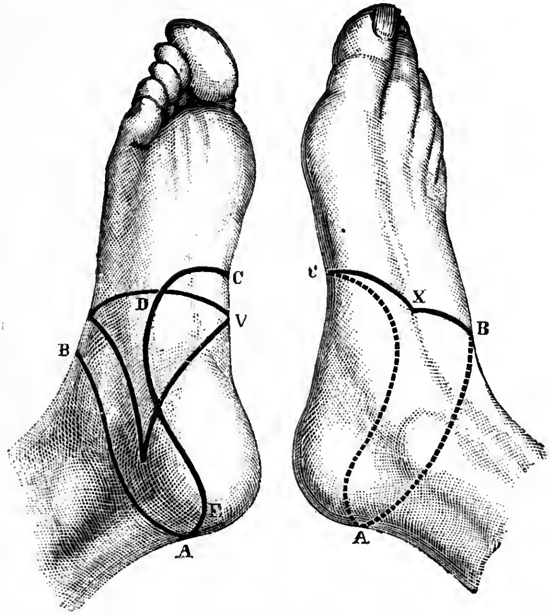

FIG. 393.—OUTER AND INNER SIDES OF THE RIGHT FOOT, TO SHOW THE INCISIONS IN FARABEUF'S SUBASTRAGALOID AMPUTATION.

V, The lines of Verneuil's subastragaloid amputation. (For other references, *see* text.)

Position and **Instruments.**—The same as in the preceding operation.

The following methods will be described :—

1. Farabeuf's operation.
2. The oval operation.
3. Verneuil's operation.
4. By the heel flap.

1. **Farabeuf's Operation by a Large Internal and Plantar Flap.**—In this procedure a large flap is cut from the sole and the inner aspect of the foot.

(1) *The Line of Incision.*—The incision is commenced at the outer margin of the tendo Achillis at its insertion (Fig. 393, A), and is then curved up a little to reach the level of a point one inch below the outer malleolus. It is now carried forwards horizontally, parallel to the outer border of the foot, and one inch below the malleolus (A to B), and reaches a point (B) which is on a line connecting the base of the fifth metatarsal bone with the joints between the scaphoid and cuneiform bones. It then curves sharply inwards across the dorsum of the foot (B to X), a little in front of the joints named, and reaches the extensor proprius pollicis tendon at X. The incision next crosses the inner border of the foot so as to follow the line of the cuneo-metatarsal joint of the great toe (X to C).

It now sweeps across the centre of the sole of the foot (C to D), and is then rounded off and curved back so as to follow exactly the outer border of the foot as far as the external tuberosity of the os calcis (E). It is now curved up a little to end at the insertion of the tendo Achillis at A. (Figs. 399, E, and 402, A.)

The foot must be turned from side to side by the surgeon's left hand as the devious line of this incision is followed. The knife at first divides only the skin and the subcutaneous tissue. It is then made to follow the incision a second time—when the skin has retracted a little—and is carried to the bone. Care must be taken that the knife goes well down to the bone, and that all the soft parts are divided. To effect this the blade must be used with considerable vigour. The border or surface of the foot that is attached must be put upon the stretch, so that the tendons are cleanly divided. The peronei tendons are especially difficult to cut. In making these deep sweeps with the knife the surgeon must take great care to avoid opening any joints, notably those between the scaphoid and the cuneiform bones.

(2) *The Disarticulation.*—The leg having been flexed upon the thigh, the assistant turns the knee in with one hand and presses the lower part of the leg against the edge of the couch with the other.

The foot projects beyond the edge of the table, with its outer surface well exposed and lying horizontally.

Let the dorsal part of the flap (X to A) be now dissected up sufficiently to expose well the head of the astragalus; divide

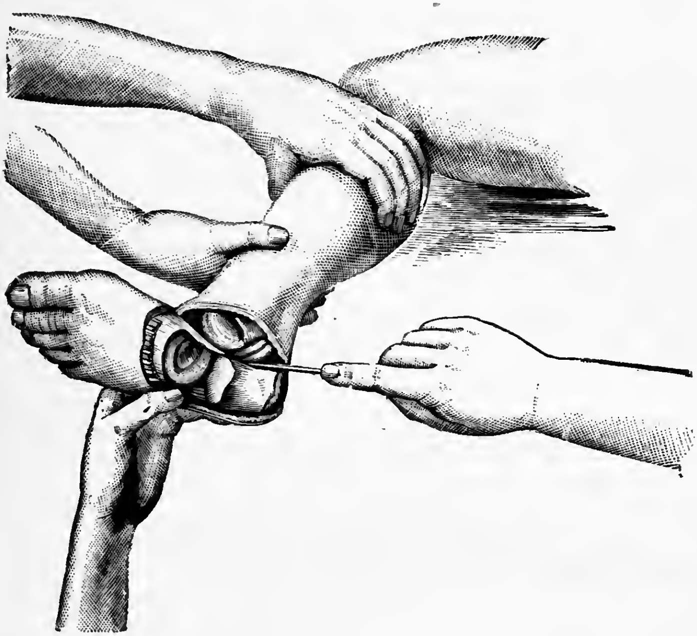

FIG. 394.—SUBASTRAGALOID AMPUTATION OF THE LEFT FOOT. (*After Farabeuf.*

the tendo Achillis; open the astragalo-scaphoid joint on its dorsal aspect. Keep the knife between the bones, and, cutting backwards, pass it between the os calcis and astragalus, and so sever the interosseous ligament. This entails no difficulty if the outer surface of the foot be well exposed and kept upon the stretch with the left hand. As the ligament is divided, turn the os calcis more and more out. See that all the tendons, etc., are divided on the outer side of the foot, and that the outer aspect of the os calcis is bared to the periosteum.

Now with the left hand twist the foot round until it is in the

position of the extremest varus. In this position dissect—by cuts made from left to right in the left foot, and from right to left in the right foot—all the soft parts from the inner and under surfaces of the os calcis (Fig. 394). Special care must be taken of the vessels which lie in the hollow on the inner side of that bone.

Clear the under-surface of the bone, still turning the foot out. When this process of enucleation is complete, the foot will have been so turned round that the dorsum will face downwards. Now separate the foot and cut any neglected tendons short. The suture line on the stump is horizontal, and is on the outer side of the extremity.

The operation is much easier on the left than on the right foot. In the latter case it may be more convenient to dissect up the great flap and bare the os calcis before the disarticulation is effected. No drainage-tube is required, as a rule.

Hæmorrhage.—In the part of the flap A to B are cut the posterior peroneal, the anterior peroneal, and branches of the tarsal and metatarsal arteries. The largest of these is the first-named, which runs just behind the malleolus.

In the part B to X the tarsal artery and the dorsalis pedis—the latter a large vessel—are divided opposite the centre of the head of the astragalus. In the part X to D the internal and external plantar are cut. In the margin of the flap D to E branches of the latter vessel are found.

2. **The Oval Operation (Maurice Perrin).**—The incision in this procedure commences behind, at the insertion of the tendo Achillis, and is carried forwards along the outer side of the foot—parallel with its external border, and one inch and a half below the external malleolus—to a point just behind the base of the fifth metatarsal bone.

It is then curved across the dorsum to reach on the inner side of the foot the level of the joint between the first metatarsal bone and the cuneiform. The incision now sweeps back across the sole and joins the first cut some two inches behind the base of the fifth metatarsal bone (Fig. 395, B).

The incision may at first involve the skin only, but must then be carried well to the bone.

The subsequent steps of the operation are precisely the same

as in the previous amputation. The foot should be placed in the same posture, and the disarticulation effected in the same manner.

It is advisable to saw off the head of the astragalus.

In the left foot the disarticulation may be carried out as soon as the dorsal and external parts of the flap have been dissected back. In the right foot the whole of the flap had better be dissected back as far as possible, and the os calcis cleared before the disarticulation is attempted.

3. **Verneuil's Operation.**—This procedure appears to be one that is very generally adopted in France (Fig. 393, V).

The incision is commenced over the outer tuberosity of the os calcis, from 2 to 3 cm. below the external malleolus. It is then carried forward to a point 2 cm. behind and to the inner side of the base of the fifth metatarsal bone. It is now curved over the dorsum of the foot to the middle of the internal cuneiform bone. Finally, it sweeps obliquely across the sole, to reach the point of commencement by the shortest possible route.

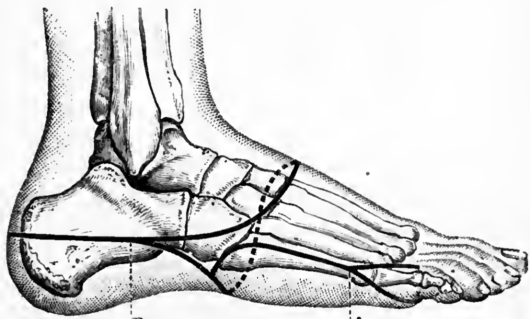

FIG. 395.—A, Disarticulation of the little toe, together with its metatarsal bone, by the oval or racket incision; B, Maurice Perrin's subastragaloid amputation.

The soft parts are cleared from the bone, and the disarticulation is effected as above described. It is advisable to saw off the head of the astragalus.

4. **Disarticulation with a Heel Flap.**—The flaps made in this operation are a modification of those of Syme's amputation (page 593). The plantar incision commences half an inch below the outer malleolus, and ends one inch below the inner malleolus. Between these points it is carried vertically downwards across the heel, while the foot is held at right angles to the leg. The dorsal flap is **U**-shaped, has its limbs horizontal, and crosses the foot, with a curve, at the level of the astragalo-scaphoid joint (Fig. 396, B).

The heel flap is dissected back just as in Syme's amputation (page 593), and the tendo Achillis is then divided. The dorsal flap is in the next place dissected up, and must include all the soft parts down to the bone.

The astragalo-scaphoid joint having been opened from the dorsum, the knife is passed between the astragalus and os calcis, and the disarticulation is effected. Ashhurst advises that, as soon as the flaps have been made, the anterior part of the foot should be disarticulated along the line of Chopart's operation, that the os calcis should then be grasped with a pair of lion forceps and twisted from side to side while the separation from the astragalus is effected.

The head of the astragalus should be removed with the saw. The vessels divided are practically the same as those cut in Syme's operation.

Comment.—Subastragaloid amputation was proposed by Lignerolles in 1839, was first performed in Germany by Textor in 1841, in France by Malgaigne in 1845, and in England by Simon in 1848. Malgaigne employed a single large internal flap, and Nélaton peculiar dorsal and plantar flaps that were larger on the inner than the outer side.

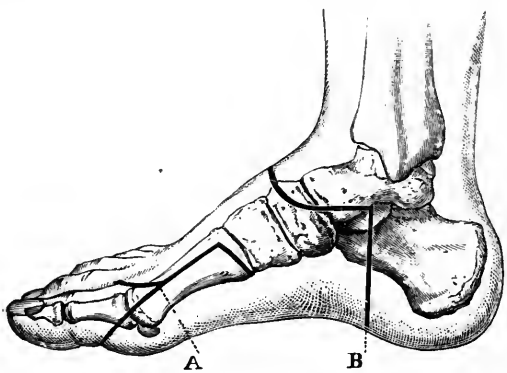

FIG. 396.—A, Disarticulation of the great toe, together with its metatarsal bone, by the oval or racket incision; B, Subastragaloid amputation by heel flap.

The amputation gives very excellent results. The astragalus forms a good surface for support, and, as the ankle-joint is preserved, a more elastic stump is produced than results from either Syme's or Pirogoff's amputation (Fig. 351, p. 460.)

The first three methods described are practically varieties of the oval or racket incision; the fourth involves a simple heel flap.

Farabeuf's operation has been considered first, because it serves to demonstrate the especial features of the operations by the oval method and the difficulties of disarticulating. The resulting flap affords an excellent covering to the bone, the head of the astragalus can be left, and the cicatrix is well removed from pressure. The incision is, however, needlessly complex, the flap is a little unwieldy, a rather large pocket is formed about the heel, and it is not easy to obtain in every

case so large a tract of sound skin as is demanded. Verneuil's operation is much simpler, but, if conducted precisely upon the lines laid down, the resulting flap is a little scanty.

Perrin's operation is difficult; the soft parts are somewhat roughly handled, and there are many risks of injuring the vessels of the flap. The heel-flap method involves a laborious dissection, in which the flap is apt to be scored, and it is not well adapted for covering the astragalus. Nevertheless it sometimes gives excellent results. In one case I (J. H.) saw the patient ten years after performing this operation. The flap had not shrunk, and the functional result was as good as could be wished.

FIG. 397.—STUMP OF SUBASTRAGALOID AMPUTATION, SEEN FROM THE OUTER SIDE.

From a photograph taken three years after the amputatfon. It will be seen that a broad surface is left for support, and that the scar is well away from the point of pressure.

When the stumps, however, have become firm, some important points of difference are to be noted: The stump in the oval operation is wide, and the cicatrix is well removed from pressure; in the heel-flap procedure the stump is narrower, and the suture-line comes inconveniently near to the pressure area. In patients in whom fair healing powers may be expected, Farabeuf's method is to be preferred.

After these operations the limb should be supported on an inclined plane on a simple back-splint. The sutures should be retained as long as possible, and after their removal the flap may be supported by strapping.

AFTER-TREATMENT OF PARTIAL AMPUTATIONS OF THE FOOT

The part should be enveloped in a large pad of soft sterilised gauze and wool, the limb should be a little raised upon a pillow, and the stump should be so placed that efficient drainage is permitted. The remarks already made with reference to the after-treatment of amputations of the toes apply to certain of these operations (page 568).

In the case of the removal of the great toe, together with its metatarsal bone, the foot should be allowed to lie a little upon its inner side, provided that direct pressure is not made upon the wound. When the fifth toe has been removed in a similar manner, the foot should be inclined towards the opposite side.

After Lisfranc's and Hey's amputations the limb may be allowed to lie upon one or other side with the knee bent. The pillow supporting the foot should be firm, the stump may project a little beyond the end of the pillow, and to this support the leg may be lightly secured.

FIG. 398.—SUBASTRAGALOID AMPUTATION BY A DEFECTIVE METHOD. THE SOLE-FLAP IS SO SMALL THAT IT WILL BE IMPOSSIBLE TO OBTAIN GOOD UNION.

After Chopart's operation and after the subastragaloid amputations the stump should be supported upon a back-splint, which is kept a little raised by a firm pillow or cushion. By this means the heel-flap is supported, and the os calcis in the Chopart operation is to a great extent kept from altering its position. The knee should be a little bent, and the stump may be inclined laterally, so as to favour drainage. The splint employed is an ordinary straight back-splint, suitably padded.

A pad is introduced beneath the tendo Achillis. The skin is protected by a piece of gutta-percha moulded to the limb and lined with lint. The splint is secured by straps and buckles.

Drainage-tubes should not be employed unless actually necessary, and should never be passed right across the angle of the wound, from one extremity of the incision to the other. A small piece of tubing may be introduced at each of the two corners of the wound—as in Hey's, Lisfranc's, and Chopart's amputations—and sutures at these points may be omitted. In any case the tubes should, in ordinary circumstances, be removed in twenty-four hours.

CHAPTER VIII

AMPUTATION AND OSTEO-PLASTIC RESECTION OF THE FOOT

I. Amputation

Two methods of amputating the foot will be described :—

1. Disarticulation at the ankle-joint.
2. Intracalcaneal amputations of the foot.

1. DISARTICULATION AT THE ANKLE-JOINT (SYME'S AMPUTATION)

This is the principal operation for removing the entire foot. The flap is made from the heel, the soft parts having been peeled off the os calcis. The two malleoli, together with the articular surface of the tibia, are sawn off.

Anatomical Points.—The mechanical character of the ankle-joint should be well known, and the height and breadth of the dome on the tibia, which receives the head of the astragalus, duly appreciated.

The anterior and posterior ligaments of the ankle-joint are very thin, but the lateral ligaments—and especially the internal lateral ligaments—are very strong, and have wide and extended attachments to the tarsal bones. The chief tendons about the ankle-joint run in synovial sheaths, and are therefore difficult to cut unless the knife be wielded with vigour.

The *blood supply* of the heel-flap is a matter of great importance ; the two chief vessels of supply are the external calcaneal of the posterior peroneal on the outer side, and the internal calcaneal of the external plantar on the inner side. The first-named vessel is a continuation of the posterior peroneal. It runs just behind the inferior tibio-fibular joint, and then behind the outer malleolus to the heel. With regard to the internal calcaneal artery, the posterior tibial divides

"on a level with a line drawn from the point of the internal malleolus to the centre of the convexity of the heel." This line is dangerously close to the line of the incision. The internal calcaneal artery arises from the external plantar, close to the bifurcation and under the fibres of origin of the abductor pollicis. Inasmuch as this is the chief vessel of the flap, the greatest care must be taken of it. (*See* page 594.)

Minute branches may reach the flap from the internal malleolar of the posterior tibial and from the outer and inner malleolar of the anterior tibial.

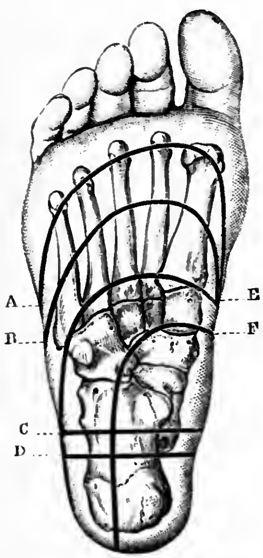

FIG. 399.—PLANTAR INCISIONS.
A, Lisfranc's; B, Chopart's; C, Pirogoff's; D, Syme's; E, Farabeuf's subastragaloid amputation; F, Farabeuf's amputation at the ankle.

The lower *epiphysis* of the tibia includes the articular surface and the inner malleolus. It joins the shaft between the eighteenth and nineteenth years. The lower epiphysis of the fibula corresponds to the outer malleolus, and joins the shaft about the twenty-first year. The os calcis has an epiphysis for its posterior extremity. It forms a cartilaginous shell for that part of the bone. It only commences to ossify in the tenth year, and joins the body of the bone at fifteen or sixteen.

In removing the lower ends of the tibia and fibula the greater part of the anterior and posterior tibio-fibular ligaments, together with the interosseous ligament, are saved, while the transverse or inferior ligament is cut away with the bones.

Instruments.—A stout narrow knife, with a blade three inches long, a narrow but rounded point, and a large strong handle; a scalpel; a saw; two metal retractors to hold back the flaps when sawing the leg bones; lion forceps; pressure forceps; artery and dissecting forceps, scissors, etc.

Position.—The patient lies on the back, with the foot projecting beyond the end of the table and the toes pointing upwards. The surgeon sits facing the end of the table. The lower end of the leg is raised on a Volkmann's pelvic support to the level of the surgeon's face. The surgeon sits to cut the heel flap, and stands to cut the dorsal flap and to disarticulate. Two assistants stand facing the surgeon, one on each side of the

end of the table. One steadies the foot, the other attends to the wound.

The Operation.—An assistant steadies the leg with one hand, and holds the foot—by the toes—rigidly at a right angle to the leg with the other hand.

(1) *The Heel Flap.*—The incision starts from the tip of the outer malleolus, and in a line nearer to its posterior than its anterior border.

It is carried vertically down the heel, exactly at right angles to the long axis of the foot, runs transversely across the sole, and passing up vertically on the inner side of the heel, ends at a point about half an inch below the tip of the inner malleolus (Fig. 399, D).

FIG. 400.—SYME'S AMPUTATION OF THE FOOT.

In making this incision, supposing the right foot to be operated on, the surgeon holds the ankle with the palm of his left hand on the dorsum of the foot, with his thumb on the outer malleolus and his forefinger on the inner malleolus.

Entering the knife at the inner starting-point, the incision is carried down to the sole and then across the plantar aspect of the os calcis, at one cut. The knife is now re-entered at the outer starting-point, and is carried down to meet the first incision at the sole. If an attempt be made to perform the incision at one cut, and to make the outer limb of the incision by cutting from the heel towards the leg, the knife may slip and cut too far up into the leg, running by the starting-point. On the left foot the same precaution is observed, but the incision is commenced on the outer side.

This incision should be carried well and cleanly down to the bone. The heel flap is now dissected back: the thumb-nail of the left hand is used with force to drag back the soft parts, while the knife is kept well on to the bone and parallel to the surface of the flap. The os calcis must be laid perfectly bare. The great point in Syme's amputation is to "keep close to the bone."

The flap must be cleared from the tuberosities of the os calcis, and then from its posterior surface.

(2) *The Dorsal Incision.*—The surgeon now holds the foot in the left hand in the position of full extension, and connects the extremities of the heel incision by a cut which simply sweeps across the front of the ankle region. The dorsal and the heel incisions are about at right angles to one another (Fig. 400). The cut includes all the soft parts down to the bone. The tendons must be cleanly divided while the foot is kept on the stretch.

(3) *The Disarticulation.*—The ankle-joint is at once exposed, the anterior ligament having been severed. The knife is now introduced into the joint and the lateral ligaments are divided, in both instances by cutting from within outwards. These complex ligaments are difficult to cut if attacked from the outer side of the articulation. The posterior ligament is cut, the upper surface of the os calcis is cleared, and by the division of the tendo Achillis the disarticulation is completed.

(4) *The Removal of the Malleoli.*—The soft parts are cleared from the two malleoli and the lower end of the tibia, great care being taken not to damage the flaps. The exposed bones are then divided by a horizontal saw-cut, the saw being applied about a quarter of an inch above the inferior margin of the tibia.

The flaps may be protected by spatulæ during the sawing. If it should be necessary, the malleoli may be held with lion forceps.

Before the wound is adjusted by sutures, a hole may be made in the centre of the heel flap, and a drainage-tube introduced.

Hæmorrhage.—The anterior tibial artery is cut in the dorsal flap just opposite the centre of the front of the ankle. The external and internal plantar arteries are divided in the inner section of the heel flap. The two vessels are close together. The following vessels may give rise to hæmorrhage: the internal malleolar of the posterior tibial behind the inner malleolus; the anterior peroneal in front of the tibio-fibular joint; the external and internal malleolar of the anterior tibial in front of their corresponding malleoli. The internal saphenous vein is cut in the dorsal flap, the external in the heel flap.

Comment.—This amputation gives admirable results, and

secures a sound and firm stump. The patient walks upon the natural tissues of the heel. The tendo Achillis forms an attachment with the mass of the cicatrix. With a properly adapted boot, a patient after Syme's amputation can walk with little appreciable lameness.

The following special points in the operation must be noted :—

(1) It is important that the flap should be accurately cut. In some text-books it is advised that the incision be carried from the tip of the outer malleolus to a point half an inch *behind* and below the inner malleolus. If this be done, there is great probability that the posterior tibial artery will be divided before its bifurcation, and the main artery of the flap (the internal calcaneal of the external plantar) be thus lost.

The following are Syme's own words :—" The incisions *must* be correctly made. A transverse one should be carried across the sole of the foot, from the tip of the external malleolus, or a little posterior to it (rather nearer the posterior than the anterior edge of bone), to the opposite point on the inner side, which will be rather below the tip of the internal malleolus." Thus the inner part of the heel flap is a little larger than the outer.

If the flap be too large, there is great difficulty in dissecting it back, and it will probably be dangerously scored and bruised in the attempt.

(2) In clearing the os calcis, the periosteum may be at the same time peeled off—as many advise—and so made to form an important constituent of the heel flap. In young subjects (under the age of fourteen years) the posterior epiphysis of the os calcis may be detached and left undisturbed in the flap.

In such subjects it generally comes away during the process of clearing the os calcis.

In still younger patients—say those under ten—the superficial parts of the os calcis will be found imperfectly ossified, and chunks of the soft bone may be cut away in a too vigorous clearing of the heel flap.

(3) It is desirable that all the articular surface of the tibia should be removed, and, as the under-surface of the bone is much domed, the section must be made as high up as a quarter of an inch so as quite to clear the summit of the concavity. In

young patients the whole of the lower epiphysis may be removed by a too liberal use of the saw; the measurement (quarter of an inch) refers to adults.

Other Methods.—*Roux's Operation.*—This is a modified form of the oval method.

The dorsal incision is commenced at the posterior edge of the outer face of the os calcis, is carried forwards below the external malleolus, and then crosses the dorsum of the foot one inch in front of the ankle-joint to a point between the tubercle of the scaphoid and the inner malleolus, and on a level with the tip of the latter process. (Fig. 401.)

The plantar incision starts from the last-named point, and curving forwards a little, crosses the inner border of the foot about the level of the scaphoid. It is then carried across the sole to a point about one inch behind the tuberosity of the fifth metatarsal bone, and thence up to the *point de départ.* The flaps are dissected back as far as possible, the foot is disarticulated, and the soft parts are then dissected away from the inner side of the os calcis in somewhat the same manner as is described in the section on Farabeuf's subastragaloid amputation.

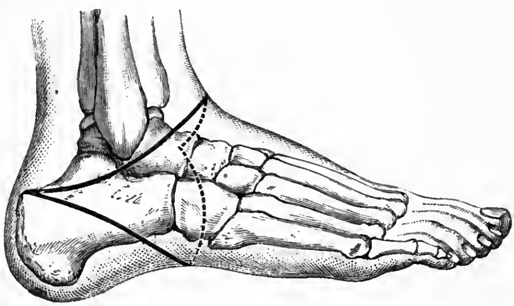

FIG. 401.—ROUX'S AMPUTATION.

The malleoli are removed as in Syme's amputation.

The procedure is difficult and tedious, and is, on the whole, inferior to Syme's operation. The flap, if well cut, is certainly better nourished, but a greater demand is made upon the integuments of the foot.

Farabeuf's Operation.—In all essential points this operation is identical with the subastragaloid amputation of the same surgeon (page 584).

The incision is commenced on the outer side at the insertion of the tendo Achillis. It is carried horizontally forward (touching the tip of the external malleolus) to a point just in front of the calcaneocuboid joint (corresponding to B, Fig. 393). It then crosses the dorsum to reach the extensor proprius pollicis tendon, just in front of the astragalo-scaphoid joint (corresponding to X, Fig. 393). It

now sweeps over the inner border of the foot, crossing the scapho-cuneiform joint (corresponding to X to C, Fig. 393, and B, Fig. 402), and is then carried back along the median line of the sole (corresponding to D to E, Fig. 393, and F, Fig. 399), to end at the insertion of the tendo Achillis. The flaps are dissected back as far as convenient, the ankle-joint is opened from the outer aspect of the foot, and the disarticulation and the clearing of the os calcis are effected precisely in the manner already described.

A good thick vascular flap is provided, but the operation is less easy to execute than Syme's, and has no distinct advantage over that admirable procedure.

2. INTRACALCANEAL AMPUTATIONS OF THE FOOT

(1) **Pirogoff's Operation.**—This operation closely resembles Syme's, save that the os calcis is sawn through and its hinder part is left in the heel flap. The lower ends of the tibia and fibula are sawn through, and to this cut surface of bone the surface of the divided os calcis is adjusted.

The operation usually described is a modification of Pirogoff's original procedure. Pirogoff divided the calcaneum vertically, and left the articular surface of the tibia, unless it was diseased.

Position and *Instruments.*—The same as in Syme's operation. The saw should either be a fine Butcher's saw, or a slender saw with a movable back. Retractors are required.

Operation.—The incisions are nearly the same as in Syme's operation, with these modifications: They commence on the outer side, just in front of the tip of the malleolus, and end on the inner side a few lines in front of the internal process. The heel incision extends a little farther forward than in Syme's operation (Fig. 399, C). It is carried well down to the bone. The soft parts are dissected backwards from the os calcis for about a quarter of an inch.

The dorsal cut is then carried out, and may be a little more convex than in Syme's amputation. The ankle-joint is opened and disarticulation effected precisely as already described.

The foot is now dragged forward and placed in the position of full extension.

The whole of the upper surface of the os calcis is exposed. The saw is now applied to this surface, one finger's-breadth

behind the astragalus, and is made to cut the bone obliquely, following the lines of the now distorted heel incision. In sawing the bone, the soft parts must be carefully retracted, and, in the position in which the foot is held, the saw runs nearly vertically (Fig. 402, C). The greatest care must be taken not to damage the arteries in the inner part of the heel flap.

The soft parts are now dissected from the lower ends of the tibia and fibula. The saw is applied to the anterior aspect of these bones, close to the articular surface of the tibia, and is made to cut so obliquely upwards that the saw emerges on the posterior aspect of the tibia, a finger's-breadth above the articular surface (Fig. 402, C). Any unduly long tendons are divided. The wound is sutured as in Syme's operation, the cut surfaces of bone being thus brought into close contact.

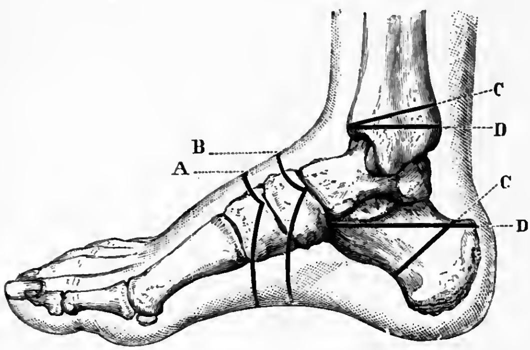

FIG. 402.—A, Farabeuf's subastragaloid amputation; B, Farabeuf's amputation at the ankle-joint; C C, Saw-cuts in Pirogoff's operation; D D, Saw-cuts in Pasquier and Le Fort's operation; D shows also the saw-cut made in the os calcis in Tripier's operation.

Care must be taken in the after-treatment that the heel fragment is not drawn up by the tendo Achillis.

The vessels divided are the same as in the preceding operation.

Comment.—Some surgeons make much larger heel flaps, carrying the incision forwards and downwards, so as to cross the calcaneo-cuboid joint, instead of directing it nearly vertically downwards from the malleoli.

This operation does not appear to have been very widely employed. It is suited for certain cases of accident, but not for cases of disease. An unhealthy state of the os calcis absolutely excludes the operation. Pirogoff obtained his unrivalled experience of it during the Russian wars, and it is rarely performed in civil practice. We have, however, seen some excellent stumps resulting from it, of which their owners were proud.

It presents these advantages when compared with Syme's operation :—

The heel flap has a better blood supply ; the stump is longer by one or two inches, is firmer, does not shrink, and contains bone ; the insertion of the tendo Achillis is not disturbed. On the other hand, Pirogoff's operation is no easier to perform than Syme's ; the piece of bone in the heel is apt to become displaced by the action of the calf muscles ; it may fail to unite, may necrose if the wound become infected, and has led to a painful stump ; a wider section of cancellous bone is left, and greater demands are made upon the healing powers. The operation would not be likely to succeed with elderly subjects. So far as movement is concerned, it has not been shown that the stump is always very decidedly improved by the retention of a portion of the calcaneum.

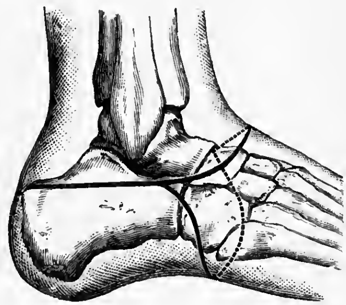
FIG. 403.—PASQUIER AND LE FORT'S OPERATION.

(2) **Le Fort's Operation.**—This is a modification of Pirogoff's procedure. It is described by Farabeuf as "Pasquier-Le Fort's operation."

The skin incisions are somewhat the same as in Roux's method, with the exceptions that the incision on the outer side is carried back to the insertion of the tendo Achillis, and the wound-lines conform to the racket rather than to the oval operation (Fig. 403).

The calcaneum is cut horizontally just below the sustentaculum tali (Fig. 402, D).

The incision having been carried to the bone, the soft parts are dissected back as far as possible, especially on the dorsum and about the external part of the wound. The ankle-joint is opened from the outer side, the anterior and external ligaments being first attacked. The disarticulation is made complete, and the foot rotated very strongly outwards, so that the astragalus presents at the outer part of the wound.

The astragalus is now seized with large lion forceps and turned (together with the whole foot) still more outwards, until at last the forceps are quite horizontal. The upper portion of the os calcis is carefully cleaned, and all the part of the bone that requires removal will now be seen in the outer wound, the inner surface of the os calcis

looking directly upwards. The saw is applied to the surface, just below the sustentaculum tali, and the bone is divided quite horizontally. The insertion of the tendo Achillis is preserved. The inferior and lateral ligaments of the calcaneo-cuboid joint having been divided, the foot is free.

The lower ends of the tibia and fibula are sawn through horizontally, just above the articular surface for the ankle-joint (Fig. 402, D).

It is claimed that this procedure is superior to Pirogoff's, on the following grounds :—A good thick flap, well supplied with blood, is provided. A larger amount of the soft parts that cover the heel is saved. The whole length of the os calcis rests upon the ground, and the patient is provided with a wider area of support. The parts are left in a more natural position.

FIG. 404.—TRIPIER'S OPERATION.

(3) **Tripier's Operation.**—This operation is really a modification of Chopart's amputation.

In that procedure some difficulty is often experienced by the tilting of the heel-stump in the position of talipes equinus. Tripier seeks to avoid this by making a wide horizontal section of the os calcis, so that the stump may present a broad and level basis of support. An excellent flap is provided.

The dorsal incision has its concavity upwards and inwards. It commences at the outer edge of the tendo Achillis, on a level with the tip of the external malleolus. It sweeps forwards about one inch below that point of bone, passes a finger's-breadth behind the tuberosity of the metatarsal bone, and ends at the inner side of the extensor proprius pollicis tendon, two fingers'-breadth in front of the ankle-joint. The plantar incision commences at this point, is carried over the inner cuneiform bone at the internal margin of the foot, sweeps with a curve across the sole, reaches the outer edge of the foot about the base of the fifth metatarsal, and then joins the dorsal incision (Fig. 404).

The incision extends to the bone. The flaps are dissected back so as to make clear the medio-tarsal joint. Disarticulation is now effected as in Chopart's operation. With a rugine the whole of the under part of the os calcis is bared of periosteum, the plantar flap

having been dissected up as high as the sustentaculum tali. The os calcis is now seized with lion forceps and so turned as to expose its inner surface well. The saw-cut is made horizontally, just below the sustentaculum, and runs from the inner to the outer surface (Fig. 402, D). The angle which the cut surface of the os calcis forms with the cuboid surface of that bone is finally rounded off with the saw, and the operation is complete.

AFTER-TREATMENT OF AMPUTATIONS OF THE FOOT

Many of the observations already made with reference to the after-treatment of amputations of the toes and of portions of the foot apply to the present procedures.

The stump should be protected from pressure of the bed-clothes

The limb should be a little raised upon a firm pillow.

A back-splint should be adjusted precisely as advised in the case of some of the previous operations (page 484 and Fig. 357).

Care must be taken that the pad of the splint does not press unduly upon the extremity of the stump. This splint serves to support the heel flap, and, in the case of the intracalcaneal amputations, it helps also to keep the osseous surfaces in contact and to restrain the action of the muscles of the calf.

The knee should in all instances be a little bent, and the stump may, when required, be inclined a little laterally, to favour drainage.

Drainage-tubes should not be employed when their use can be avoided. They should never be passed—as is sometimes done in Syme's operation—right across the angle of the wound from one extremity of the incision to the other. In the intracalcaneal methods a short piece of tub'ng may be inserted at the most dependent part of the wound, or the wound be allowed to gape a little at that point.

Where a heel flap exists, with a pouch beneath, left by the removal of the cs calcis—as in Syme's operation—a hole may be made into the pouch through the centre of the flap, and a short length of tubing introduced. This need not be retained for longer than a day.

When the major flap is formed from the heel or sole, it should be remembered that the tissues of those parts are usually tough and unyielding, and that consequently an undue strain comes

upon the sutures. These should be deeply inserted, and should not be removed too soon. In a "Syme" they may often be retained for ten days. After their removal it may be necessary to support the flap with strips of strapping.

II. Osteo-plastic Resection of the Foot

This operation was designed by Wladimiroff in 1872, and independently by Mickulicz in 1881. It consists in the removal of the soft parts covering the heel, together with the os calcis and astragalus, and in bringing into contact the sawn surfaces of the tibia and fibula on the one hand and those of the cuboid and scaphoid on the other. The foot is thus fixed in the position of talipes equinus, and the patient walks upon the balls and phalanges of the toes. The whole of the skin covering the heel is of necessity lost.

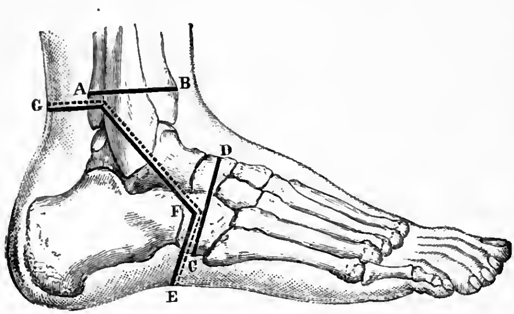

FIG. 405.—OSTEO-PLASTIC RESECTION OF THE FOOT.
A B and C D, Saw-cuts ; E F G, Skin incisions.

Operation. — The foot must be brought well beyond the end of the table, and, the knee having been bent, the foot is turned upon its side. Or the patient may be more conveniently placed in the prone position, the heel being thus directed upwards.

The same *instruments* are required as are used in Pirogoff's operation, with the addition of a periosteal elevator. The following are the steps of this somewhat complex procedure :—

1. A transverse incision is made across the sole of the foot from the tuberosity of the scaphoid to a point a little behind the base of the fifth metatarsal bone. From the extremities of this cut an incision is carried obliquely upwards and backwards, on either side of the foot, to the bases of the malleoli. The two extremities of the cut are finally connected by a horizontal incision which crosses over the tendo Achillis and completes the wound (Fig. 405, E,F,G). The incision is carried well down to the bone at all parts. The plantar vessels are divided at the inner part of the wound, on its plantar aspect.

2. The foot is now flexed to its utmost upon the leg, and while

in this position the ankle-joint is freely opened from behind, the tendo Achillis having been, of course, divided, together with all the ligaments. Disarticulation at the ankle is effected and the foot still further flexed upon the leg.

3. The soft parts of the dorsum are now separated from the astragalus with an elevator, the instrument travelling from behind forwards. This may be done subperiosteally, so as to avoid any injury to the anterior tibial artery or the extensor tendons.

4. The calcaneo-cuboid and astragalo-scaphoid joints are opened from above, and the whole of the heel, together with the os calcis and astragalus, is removed.

5. The lower ends of the tibia and fibula are now sawn through horizontally, high enough up just to clear the articular surface of the former (Fig. 405, A, B). The joint-surfaces of the scaphoid and cuboid are removed by a vertical saw-cut (Fig. 405, C, D).

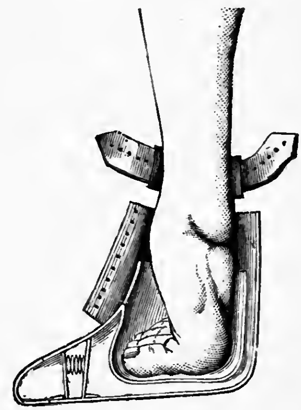

FIG. 406.—ASPECT OF LIMB AND INSTRUMENT TO BE WORN AFTER OSTEO-PLASTIC RESECTION OF THE FOOT. (*Brit. Med. Journ.*, May, 1888.)

6. The two cut surfaces of bone are brought together, and are retained in contact by sutures of kangaroo-tendon or of silver wire; the divided ends of the post-tibial nerve are united if possible. The superficial wound is closed and drained, and the foot—now in the position of extreme talipes equinus—is fixed upon a special splint and secured in position by a plaster of Paris dressing.

The soft parts on the dorsum are redundant, and are thrown into folds, but in time they shrink and the surface becomes even. The limb, if adjusted to a splint in the first instance, should be fixed in plaster of Paris as soon as possible. When the patient begins to walk, a special boot has to be worn (Fig. 406), so as to maintain the parts rigidly in the position of talipes equinus.

It is claimed that osseous union takes place between the cut surfaces of bone. The parts beyond the operation area are nourished by the dorsalis pedis artery and by its anastomoses with the plantar vessels.

As a result of the operation the limb is usually a little lengthened.

Comment.—Dr. Fenger has collected nineteen examples of this procedure, in thirteen of which the operation was performed for tuberculous caries. Out of the full number two died, some six or

eight months after the operation, of general tuberculosis; twelve made a good recovery and walked with more or less ease; in five a failure followed, with the result that in three cases amputation of the leg was called for.

The indications given for the procedure are the following: Extensive injuries of the heel region; caries of the os calcis and astragalus, with disease of the neighbouring joints; cases of destructive and intractable ulceration of the skin of the heel; some instances of cicatricial contraction of the foot, with inconvenient deformity. This operation is still on its trial, and has been subjected to much adverse criticism. The supporters of it probably lay too much stress upon the importance of preserving every possible scrap of the foot. It is a question whether the patients subjected to this operation would walk better than, or even as well as, those who had had the entire foot removed and had been provided with a good artificial limb. The present operation should not be entertained when the integuments of the heel are sound, because it is certainly a procedure inferior to Syme's amputation. The process of recovery is very slow; some of the patients were unable to walk well until seven, twelve, or fifteen months had elapsed; others, on the other hand, could walk without the boot.

Moreover, the operation, to be successful, requires good powers for repair, and such powers are not always to be expected in the subjects of tuberculous caries. The operation requires a perfectly sound condition of the integuments of the dorsum of the foot—a condition well adapted for a supramalleolar amputation with a long anterior flap.

The operation would seem to be best suited to cases of intractable ulceration of the heel, to cases of gunshot injury, and to some examples of inconvenient deformity.

CHAPTER IX

AMPUTATIONS OF THE LEG

Amputation of the leg was at one time performed almost exclusively at the "place of election," i.e. at a point a hand's-breadth below the line of the knee-joint.

At this point the bones were divided. The selection of this spot was determined by the subsequent needs of the patient. The only prosthetic apparatus he could avail himself of was the "box-leg" or "peg-leg." With this appliance the knee was maintained bent, and the weight of the body was supported upon the tubercle and tuberosities of the tibia. The amputation at the place of election secured this *point d'appui*, and at the same time left no inconveniently long stump projecting backwards from the peg-leg.

The great improvements effected in modern times in artificial limbs, and in the apparatus adopted for cases of amputation, have entirely disturbed the "place of election." The general rule in present operative practice is to remove as little of the limb as possible, it being recognised that the danger to the patient increases—other things being equal—with the height of the amputation. An artificial support can be adapted to the stump that will allow the limb to be retained in its normal position, and will permit the movements of the knee-joint to be still made use of. Even if the amputation be performed at the old place of election, it is by no means necessary that the weight be borne upon the anterior surface of the tibia. In an amputation at so high a level an artificial limb can still be employed which will enable the patient to retain the use of the knee-joint.

It comes to pass, therefore, that in amputations of the leg the stump must be able to bear pressure, the bones must be well covered, and the cicatrix should not be terminal. On this account the circular method is in no way adapted for these operations, and the same remark applies to amputation by lateral flaps of equal size. In both these procedures the resulting cicatrix must be terminal and exposed to pressure.

If in amputating at the old place of election it is determined to

use the peg-leg, and to forgo the use of the knee, then this question of pressure upon the end of the stump ceases to be of moment, and the circular amputation, or the amputation by equal lateral flaps, may be carried out. It may certainly be said that for amputations below the old place of election the two last-named methods are quite unsuited.

With regard to the *planning of flaps*, it is needless to point out that the soft parts covering the front of the limb are comparatively scanty, and are not particularly well supplied with blood. On the posterior aspect of the limb are extensive muscular layers and two large blood-vessels. On anatomical grounds a posterior flap is to be preferred to an anterior one, inasmuch as it affords a better covering to the bone, is better adapted to resist pressure, and has a fuller and more evenly distributed blood supply.

In any case in which the major flap is the posterior one, the posterior tibial nerve should be dissected out, so that it may not be exposed to the otherwise inevitable pressure. This precaution was insisted upon by Hey many years ago.

A large anterior flap must of necessity be composed to some extent of skin alone. In the upper third of the limb a very excellent flap may be cut from the antero-external aspect of the leg, which has not this disadvantage. This is the large external flap (page 621), which includes in its whole length the anterior tibial artery.

In general terms, it may be said that the cutting of flaps by transfixion in these amputations is to be condemned. This especially applies to the formation of the posterior flap. A flap so cut is apt to be uncertainly fashioned as regards its shape and thickness. The main blood-vessels of the calf can scarcely escape unnecessarily high division. Moreover, the very unequal manner in which the flexor muscles at the back of the leg retract on division renders it desirable that these muscular planes should be divided with precision.

Before sawing the bones, the interosseous membrane should be carefully divided with a scalpel, so that it may not be grazed by the saw. In " dissecting up " flaps—i.e. in separating the soft parts they contain from the bones and the interosseous membrane—the forefinger and the handle of the scalpel should be freely used in the place of the cutting blade.

General directions as to the mode of sawing the bones of the leg are given on page 625.

Stumps left after amputation of the leg are apt to become conical, especially in the lower part of the limb.

The amputations may be dealt with in three regions :—

I. Supramalleolar amputation.
II. Amputation through the middle of the leg.
III. Amputation at the "place of election."

I. Supramalleolar Amputation

Anatomical Points.—These amputations concern the lower third of the leg. In this region the tibia has become more rounded, and its sharp crest has entirely disappeared. The bone is expanded transversely at the level of the base of the malleolus, while just above that point the shaft is comparatively slender. The interosseous space is disappearing, and before the ankle is reached the tibia and fibula are in close contact.

The upper band of the anterior annular ligament passes transversely across the limb, above the level of the malleoli, is attached to both the tibia and fibula, and binds down the vertical portion of the extensor tendons. The whole region is surrounded by tendons. To the lower third of the tibia no muscular fibres are attached ; therefore the tibial side of a flap is easily separated. To the corresponding part of the fibula are attached portions of the muscular origin of the extensor communis digitorum, extensor proprius pollicis, and peroneus tertius in front, of the peroneus brevis externally, and of the flexor longus pollicis behind.

When the lower third of the limb is reached, the gastrocnemius and soleus have joined, while the muscular fibres of the latter muscle are rapidly disappearing into the tendon. The other tendons about this segment of the leg, viz. those of the tibialis anticus, tibialis posticus, peroneus longus, and flexor longus digitorum, are still accompanied by muscular fibre. The tendons most free of muscular tissue are those of the tibialis anticus and peroneus longus. The largest muscular mass near the ankle belongs to the flexor longus pollicis.

The anterior tibial artery lies in front of the tibia, between the tibialis anticus and extensor communis digitorum, and is crossed obliquely by the extensor proprius pollicis. The nerve is placed to its outer side. The peroneal artery lies close to the inner border of the fibula, under cover of the flexor longus pollicis, and just above the malleolus breaks up into the anterior and posterior peroneal vessels. The posterior tibial artery is comparatively superficial at the lower third of the leg ; it lies behind the inner part of the tibia, and skirts the outer border of the flexor longus digitorum muscle. To its outer side lies the posterior tibial nerve.

The long saphenous vein passes in front of the inner malleolus, while behind the external malleolus runs the short saphenous vein.

Methods.—The following methods of operating will be described :—

1. Oblique elliptical incision (Guyon's operation).
2. Modified circular.
3. Oblique elliptical (Duval's operation).
4. Large posterior flap.
5. Teale's amputation.

Instruments.—A small amputation-knife, with a blade of about five inches ; a stout, somewhat narrow knife, with a blade four inches long, a narrow but rounded point, and a large, strong handle (this would be a modified resection knife, and is required for Guyon's operation ; it may also be used to separate the anterior or posterior flap from the bones in the other amputations) ; a scalpel, an amputating-saw, retractors, Wells' artery and dissecting forceps ; scissors, etc.

Position.—The patient lies on the back, with the foot and lower part of the leg projecting well beyond the end of the table. The surgeon should stand to the outer side of the right limb and to the inner side of the left. In performing Guyon's amputation, he may more conveniently take up his position at the foot of the table. One assistant stands or sits facing the end of the table. He holds the foot, and manipulates it when required, during the operation. A second assistant stands facing the surgeon, and attends to the sponging, etc.

1. **Amputation by Oblique Elliptical Incision** (*Guyon's Operation*).—This operation a little resembles Syme's amputation. It allows the terminal part of the stump to be covered by the tissues of the back of the heel, and involves a low division of the bones. It can rightly be termed a supramalleolar amputation, and the medullary canals of the bones are not opened by the saw.

The incision commences in front, at a point just opposite the line of the ankle-joint, and ends behind, over the summit of the curve of the heel. Between these points the incision sweeps in a slightly curved manner from above downwards across the ankle. The cut on the inner side just skirts the malleolus ; on the outer side it passes a little in front of the corresponding process (Fig. 407, A).

In making the skin incision the surgeon holds the foot in his left hand, and manipulates it himself. In dealing with the right foot it is convenient to turn the foot inwards, and to commence the incision at the heel and on the outer side. The knife then traverses the external side of the limb, and reaches the front of the ankle. The foot being

now turned outwards, the incision is carried back along the inner side of the foot to the heel again. On the left side, the foot having been turned inwards, the incision may be commenced in front, and be carried back to the heel along the outer aspect of the limb. When the foot has been turned outwards, the ellipse is completed by drawing the knife from the heel to the starting-point across the inner side of the ankle.

The first incision involves merely the skin and the subcutaneous tissues. The surgeon then proceeds to dissect up the posterior or

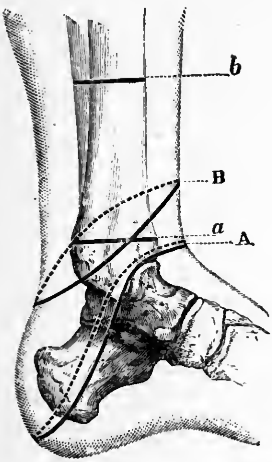

FIG. 407.—A, Guyon's supramalleolar amputation: *a*, Saw-line for that operation; B, Duval's supramalleolar amputation: *b*, Saw-line for that operation.

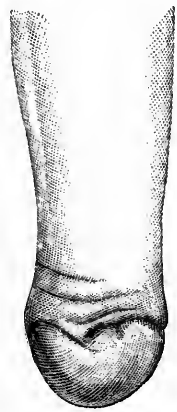

FIG. 408.—STUMP LEFT BY GUYON'S SUPRAMALLEOLAR AMPUTATION. (*After Farabeuf.*)

heel flap. This must include all the soft parts down to the bone. An exception may be made of the peronei tendons behind the external malleolus. They need not be disturbed, and should not be divided until a level above the ankle-joint has been reached. Great care must be taken of the vessels on the inner side of the os calcis. The tendo Achillis is cut, and the soft parts are cleared away from the bones of the leg up to a point about two inches above the tips of the malleoli. It is convenient to sit in order to dissect up the posterior flap.

The foot should now be extended, and the anterior incision carried well down to the bone, care being taken to avoid opening the ankle-joint. The soft parts on the front of the leg are dissected up to the level named.

Retractors having been adjusted, the bones are divided horizontally well above the bases of the malleoli.

The posterior tibial nerve should be dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided near the anterior border of the tibia. The posterior tibial vessel is cut at the inner side of the heel flap, and the termination of the peroneal at the outer side. In the soft parts in front of the outer malleolus the anterior peroneal is divided.

Comment.—This amputation would of course not be performed should Syme's operation be possible. The stump, when the margins of the wound have been united by suture, looks a little clumsy. The cicatrix, however, is transverse, is well on the anterior aspect of the limb, and is removed from the line of pressure. A good stump is ultimately provided, one valuable feature of which consists in the covering furnished by the integuments of the heel (Fig. 408). The amputation permits of a very low division of the bones.

2. **Modified Circular Amputation.**—This method has been recommended for this region, and appears to have been frequently practised by French surgeons (Fig. 412, A). A circular incision is made into the soft parts just above the malleoli and about $1\frac{1}{2}$ inches, or 4 cm., below the point at which the bones are to be sawn. This is joined by a vertical cut, in the middle of the leg, which is carried up to the level of the saw-line along to the inner side of the tibial crest.

The anterior skin flaps—i.e. the flaps (such as they are) on either side of the vertical wound—are dissected up as far as possible. The circular incision is not disturbed after the integuments have been well freed. All the soft parts down to the bone are now divided by one sweep of the knife, held very obliquely.

The operation is easy to perform, but is not to be recommended. The skin covering of the bones is a great source of weakness; the cicatrix occupies the end of the limb, and is exposed to pressure; and a conical stump can hardly be avoided.

3. **Amputation by Oblique Elliptical Incision** (*Marcellin Duval's Operation*).—In this operation the bone is divided much higher up than in Guyon's amputation. An oblique elliptical incision is made around the limb above the malleoli.

The incision is thus planned:—The point at which the bones are to be divided having been determined upon, the lower or posterior extremity of the ellipse should reach a distance below that point equal to not less than the antero-posterior diameter of the limb at the level of the saw-cut. The higher, or anterior, extremity of the ellipse should be no less distance below the proposed saw-cut than that equal to half the antero-posterior diameter (Fig. 407, B).

In effecting these measurements allowance must be made for

retraction of the skin. Thus—as Farabeuf says—if the antero-posterior diameter at the level of the saw-cut be 8 cm., then the posterior end of the incision should reach a point 12 cm. below that level, while the anterior extremity of the skin-cut should be 6 cm. below the same. The incision is inclined at about 45 degrees.

The *position* of the surgeon has been already indicated (page 608). An assistant manipulates the foot. On both the right and the left limb the wound can be more conveniently commenced at the posterior aspect of the leg.

The first incision includes the skin only. The skin is well separated, and is allowed to retract. The knife—kept close to the margin of the retracted skin—is now made to traverse all the soft parts down to the bone. The tendo Achillis is cut early. The tissues, on both the anterior and posterior aspects of the limb, are dissected up to a little beyond the level of the proposed saw-cut.

This dissection is by no means easy, especially on the peroneal side of the limb. The bones must be well bared. In dissecting up the posterior tissues the surgeon may sit and have the leg well raised in front of him. After the bones have been divided the posterior tibial nerve is dissected out. Some surgeons advise that the tendo Achillis be connected by deep sutures with the divided ends of the anterior muscles.

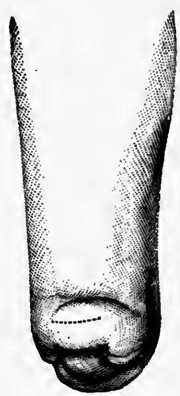

FIG. 409. — STUMP LEFT BY M. DUVAL'S SUPRA-MALLEOLAR AMPUTATION. (*Farabeuf.*)

Hæmorrhage.—The anterior tibial artery is divided in front of the tibia, the posterior tibial behind the base of the inner malleolus, the posterior peroneal behind the outer malleolus, and the anterior peroneal in the posterior flap opposite the lower end of the interosseous space.

Comment.—This operation would be very difficult should there be any matting together of the soft parts from chronic disease.

The stump looks a little clumsy at first. The cicatrix is transverse, and is placed upon the anterior aspect of the stump (Fig. 409). It is nearer the extremity of the stump than is the scar in Guyon's amputation.

4. **Amputation by a Large Posterior Flap.**—This operation, which is accredited to Tavignot in 1840, has been much modified from time to time. The present account follows the directions given by Farabeuf. Two flaps are made, the posterior being the larger. The

length of the posterior flap, when completed, is equal to that of half the circumference of the limb at the saw-line. This is after retraction has been allowed for. As the flap may be considered to lose about one-third of its length by retraction, the posterior flap, as originally marked out on the skin, will to this extent exceed in length the measurement given.

The anterior flap is about one-fourth of the posterior. The flaps may be conveniently fashioned as shown in Fig. 414, A. The posterior flap reaches, so far as the skin limit is concerned, to about the insertion of the tendo Achillis. The internal vertical incision which limits it descends in front of the inner border of the tibia. The external vertical incision lies behind the fibula.

(1) The surgeon stands in the position already indicated. On the right side the foot should be turned well out, and the inner vertical incision made from above downwards to the level of the insertion of the tendo Achillis. The foot being now turned inwards, the external vertical incision is made in like manner from above downwards, and meets the companion cut at the tendo Achillis insertion. On the left limb the foot may at first be turned inwards, and the cutting of the flap be commenced on the outer side. The incision should involve the skin only, and should be so made that the integuments can retract well all round. The tendo Achillis is now divided.

(2) The next step in the operation must be carefully performed. The limb having been well turned upon its outer side, an incision is made through the exposed muscles down to the tibia. This deep incision, which follows the line of the skin-cut, may be about two inches in length. It should be deepened by separating the muscles from the tibia. The limb is then turned upon its inner side, and a like incision is made down to the fibula, and the wound is deepened, so far as it extends, by separating the muscles from that bone. In this manner two deep lateral slits or gaps (*fentes*) are made down to the bones through the whole thickness of the posterior flap.

The thumb having been thrust into one of these gaps, and the forefinger into the other, the soft parts at the back of the limb can be pinched up by the surgeon's left hand. The foot is maintained in the flexed position, while the posterior flap is completed by cutting from without inwards (as shown in Fig. 413). The posterior flap so fashioned leaves the bones and the interosseous membrane practically free.

(3) The anterior flap is now cut. The soft parts are divided down to the bones as soon as the skin has fully retracted, and are then

dissected up so as to leave the bones and the interosseous membrane on this aspect of the limb practically bare also.

(4) Retractors having been adjusted and the interosseous membrane divided, the tibia and fibula are sawn through; the posterior tibial nerve is dissected out and removed.

Deep sutures may be passed between the muscular masses upon the front and back of the limb.

Hæmorrhage.—The anterior tibial artery is cut in the anterior flap, in front of the interosseous space. The posterior tibial and peroneal vessels are divided posteriorly, the former about the middle of the flap, and the latter in a line with the fibula. The internal

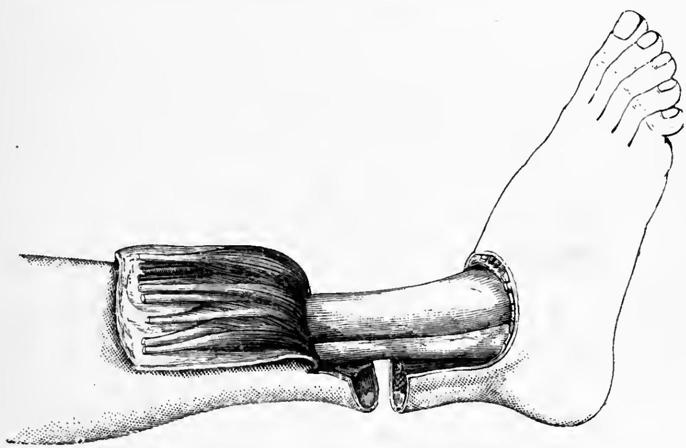

FIG. 410.—TEALE'S AMPUTATION OF THE LEG.

saphenous vein may be cut in making the internal vertical incision. It usually, however, lies wholly in the posterior flap, at the lower and inner angle of which it is found divided.

Comment.—The stump has prominent "ears," and at first may look a little clumsy. It generally, however, turns out admirably. The bones are well covered by the thick posterior flap, and the cicatrix, which is transverse, is well removed from the line of pressure.

5. **Teale's Amputation by a Large Anterior Flap.**—The lower third of the leg is considered to be a particularly favourable position for the practice of Teale's amputation.

Even here, however, grave objections may be raised to it. (*See* page 615.) The circumference of the limb having been taken at the level of the future saw-line, the anterior flap is so marked out

that in its length as well as in its breadth it shall be equal to one-half the circumference.

The posterior flap should be one-fourth the length of the anterior flap, and will include the remaining half of the circumference of the limb (Fig. 410). The lateral incisions follow the margins of the tibia and fibula. The limits of the greater flap may be conveniently marked out upon the skin with ink.

The anterior flap may be commenced on the inner side of the limb on the right side, and on the outer aspect on the left side. The two lateral incisions should be made by cutting from above downwards. It should be remembered that the anterior flap is rectangular, and of the same size all the way down.

The incision marking out the great flap should at first concern the skin only. The incision is then deepened down to the bones. The foot should be extended while the tendons at the end of the flap are being divided.

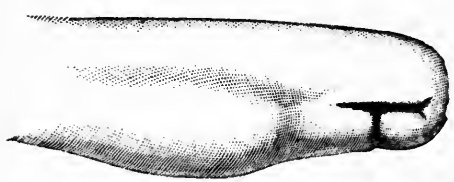

FIG. 411.—STUMP LEFT AFTER TEALE'S AMPUTATION OF THE LEG.

The anterior flap should contain all the soft parts on the front of the limb. These should be carefully dissected up from the bones and the interosseous membrane. The flap contains the anterior tibial artery in its whole length. The posterior flap may be completed by a simple vigorous transverse cut across the back of the limb from the skin to the bones. The foot should be flexed during this manœuvre. The flaps having been retracted to a little beyond the saw-line, the retractors are applied, the interosseous membrane is divided, and the bones are sawn through. When the wound has been closed by sutures, the stump has the appearance shown in Fig. 411.

Hæmorrhage.—The anterior tibial vessels are divided at the free lower end of the anterior flap, and at about its middle. The posterior tibial artery is found cut upon the face of the posterior flap and towards its inner side, the vessel lying between the margins of the flexor longus digitorum and flexor longus pollicis. The peroneal vessels are divided on the outer part of this flap, close to the fibula, and under cover of the flexor longus pollicis. The long saphenous vein will be found in the anterior flap, the short saphenous in the posterior flap.

Comment.—Inasmuch as the leg narrows towards the ankle, it is easy, by following the general lines of the limb, to make the anterior flap too narrow below.

It is claimed for this amputation that the bones are covered by a flap which does not contain too much muscular tissue, and which possesses an artery in its entire length. It is also urged that the cicatrix is placed at the back of the stump, and is not exposed to pressure.

The operation has not been received with so much favour in other countries as it apparently enjoys in England. It is an amputation of little utility and of limited application.

The main bone to be covered at the end of the stump is the tibia. The anterior flap affords this bone in large part a covering of skin only, and the integuments on the front of the leg are usually quite thin. The anterior flap, moreover, is of very unequal thickness, containing skin only at its inner part, and a substantial mass of muscle at its outer side. It has been pointed out that a portion of the anterior flap may be cut from the dorsum of the foot; but the tissues of that part are ill adapted to form the free end of a principal flap. The skin there is very thin, the subcutaneous tissue is scanty, and the soft parts beneath are represented almost exclusively by tendons. Teale's amputation makes a great demand upon the structures on the anterior aspect of the limb, and involves a comparatively high division of the bones.

Further, the doubling of the artery upon itself round the end of the bone is a drawback. As a matter of fact, the resulting stump is so poorly nourished and so apt to ulcerate that in some cases no pressure whatever on it can be borne.

Of the operations above described, it may be said in general terms that Guyon's amputation is the best when a low division of the bones is possible, and that the most suitable mode of amputating the leg in its lower third is by means of the long posterior flap.

Should the tissues at the posterior aspect of the limb be much damaged, Teale's operation may be conveniently carried out.

II. Amputation Through the Middle of the Leg

Anatomical Points.—At the middle of the leg the limb is very muscular, the mass of muscles in the calf being considerable. The main muscle in front of the interosseous membrane at this level is the tibialis anticus. The extensor communis digitorum is of fair size, the extensor proprius pollicis is as yet small. All these muscles are attached to the bones. The anterior tibial artery lies in front of the interosseous membrane, midway between the two bones, and is very deeply placed. At the back of the limb the main muscular mass belongs to the soleus. The muscle is free except at its inner side

where it is still attached to the internal border of the tibia. It is capable, therefore, of some retraction when divided. The plantaris tendon is free. The gastrocnemius at this level is still muscular. On section its bulk is seen to be scarcely equal to a third of the bulk of the soleus. It is quite free from bony attachment, and can therefore retract readily when divided. The freedom of the gastrocnemius and soleus muscles is of primary importance in the execution of Henry Lee's operation.

The remaining muscles at the back of the limb are all attached to the bones, and are not therefore capable of retraction. Of these, the tibialis posticus is the largest; the flexor longus digitorum is of fair size, while the flexor longus pollicis is as yet small.

The peroneal artery lies close to the fibula, under cover of the last-named muscle. The posterior tibial vessels lie in the groove between the tibialis posticus and the flexor longus digitorum. At the outer side of the limb are the two peronei muscles, both attached to the fibula. The peroneus longus at this level is very large, the peroneus brevis very small.

With regard to the operations which may be performed at the middle of the leg, reasons have been already given for condemning the circular amputation and the cutting of a posterior flap by transfixion (page 606).

Teale's operation is sometimes advised for this position. The objections, however, which have been urged against that amputation in the lower third of the leg apply equally to this section of the limb. The anterior flap is of considerable length, and the bones have to be divided at an unnecessarily high level. The operation may be carried out when the soft parts at the back of the limb have been extensively destroyed.

The two procedures best adapted for this region are the following:—

1. **Amputation by a Large Posterior Flap** (*Hey's Operation*). *Instruments.*—An amputating-knife with a blade about five inches in length; a stout scalpel; an amputating-saw; retractors (the linen retractor used to protect the parts during the sawing of the bones may have three tails, the central and narrower slip being passed through the interosseous space); pressure forceps; artery and dissecting forceps; a periosteal elevator or rugine; scissors, etc.

Position.—The patient lies upon the back, with the leg and knee beyond the end of the table. In dealing with the right limb, the surgeon stands to the outer side of the leg; in dealing with the left limb, to the inner side. One assistant stands or sits facing the end

of the table. He holds the foot and leg, and manipulates it during the operation. A second assistant stands facing the surgeon and to the left of the patient, and attends to the sponging, etc.

Operation.—Hey's operation is described in his "Practical Observations" (3rd edition, 1814, page 526). The procedure here detailed is a slight modification of Hey's method. Hey cut the posterior flap by transfixion, and made a slightly shorter anterior flap.

The circumference of the limb at the saw-line having been noted, the posterior flap is so made that its length and breadth are equal to a third of that measurement —i.e. are equal to the diameter of the limb.

The anterior flap is about a third of the length of the posterior one. The large posterior flap is **U**-shaped. The main incisions are commenced about one inch below the point at which the bones are divided. The inner limb of the **U** of the posterior flap is just behind the internal border of the tibia, while the outer limb of the **U** runs posterior to the peronei muscles (Fig. 412, B). These muscles are consequently found divided in the anterior flap.

(1) The operation is commenced by cutting the large flap.

On the right side the limb is turned upon its outer surface (i.e. with that surface looking downwards), the knee is flexed, and the inner vertical incision is made from above downwards. The inner segment of the bend of the **U** is then completed. The leg is now turned upon its inner side, and the outer vertical incision is made by cutting from above downwards. On finishing it, the bend of the **U**, the terminal part of the flap, is completed (Fig. 412, B). On the left leg the limb may be first turned upon its inner side (i.e. with that surface looking downwards), and the operation be commenced by cutting the outer vertical incision.

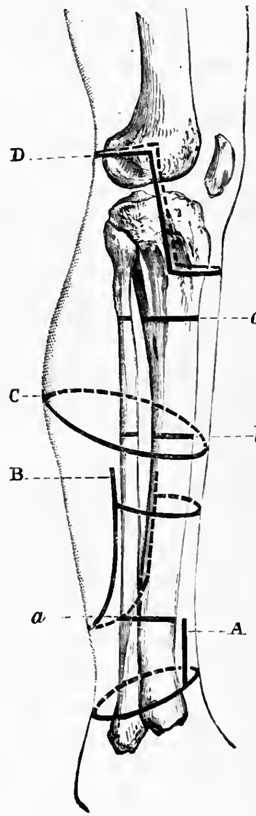

FIG. 412.—A, Modified circular supramalleolar amputation: *a*, Saw-line of same; B, Hey's amputation: *b*, Saw-line of same; C, Circular amputation at "the place of election" *c*, Saw-line of same; D, Gritti's operation.

The incisions thus made concern the skin only, and the integuments are well freed along all parts of the cut.

(2) The leg is now flexed upon the thigh, and the knee turned outwards so as to expose the calf. When in this position, and while the foot is flexed, the gastrocnemius muscle is picked up between the fingers and thumb and is divided transversely at the level of the retracted skin.

(3) Two short, deep, vertical incisions are now made from above downwards through the soft parts at either margin of the flap. These

FIG. 413.—MODE OF DIVIDING THE TISSUES IN THE AMPUTATION BY A LARGE POSTERIOR FLAP.

incisions extend to the bone: the inner direct to the tibia, the outer to the fibula behind the peronei muscles.

Into the gaps thus made the thumb and fingers of the left hand are inserted, and the muscles of the calf, being firmly grasped, are lifted up from the bones. (*See* Fig. 413.)

The muscles are now carefully separated from the bones along these two short lateral incisions with a stout scalpel until the middle of the flap is entirely free, and the thumb and forefinger can be made to meet between the deep muscles and the bones. These muscles and the vessels they carry with them are finally divided at their lower parts by a vigorous transverse cut. To effect this, the amputating-knife is introduced between the separated muscles and the bones, and is made to cut from within outwards. The posterior flap is now quite free below, and the soft parts above are cleared away from the tibia and fibula and intervening membrane until the level of the saw-cut is reached.

(4) The anterior flap is made by passing the knife in a curved manner across the face of the limb. The incision at first involves the skin only. When retraction has taken place, the muscles are cleanly divided down to the bones. These muscles are then dissected up as far as the level of the future saw-cut, the interosseous membrane being thus bared in front as well as behind.

(5) Retractors having been applied, and the interosseous membrane divided transversely, the bones are sawn through. The periosteum may be separated from the lower end of the tibia.

The prominent projection of the anterior border of the tibia should be removed with the saw in the manner described on page 624.

The posterior tibial nerve is dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided at the free end of the anterior flap, the posterior tibial and peroneal vessels at the free margin of the posterior flap. The position of these vessels has been already indicated.

2. **Amputation by Large Posterior Flap** (*Henry Lee's Operation*).—An account of this operation is given in the *Med.-Chir. Trans.* (vol. xlviii., page 195).

The instruments required, and the position of the patient and of the operator, are precisely the same as in the previous amputation.

The same order may be observed in making the incisions.

The flaps are measured and fashioned, so far as the skin incisions are concerned, precisely upon the lines of Teale's operation, with the difference that the main flap is upon the posterior instead of upon the anterior surface of the limb. The principal flap, moreover, instead of containing all the soft parts covering the bones, carries with it only the superficial flexor muscles of the calf. Both flaps are rectangular. The anterior flap is one-fourth the length of its fellows (Fig. 420, B). The relation of the incisions to the saw-line is the same as in Teale's method. Both flaps are marked out with the knife, the incisions involving at first the integuments only. The anterior flap is the first to be completed. The subsequent steps are thus described by Mr. Lee :—

" When the skin has become somewhat retracted by its natural elasticity, an incision is carried through the parts in front of the tibia, interosseous membrane, and fibula. The whole of the parts thus divided are separated close to the periosteum and interosseous membrane, and are reflected upwards to a level with the upper extremities of the first longitudinal incisions.

" The deeper structures at the back of the leg are then freely divided in the situation of the lower transverse incision. The conjoined

gastrocnemius and soleus muscles are separated from the subjacent parts, and are reflected as high as the anterior flap. This part of the operation is performed with the greatest facility on account of the loose attachments of these muscles, especially at the lower part of the leg.

"The deeper layer of muscles, together with the large vessels and nerves, is divided as high as the incisions will permit, and the bones sawn through in the same situation."

The prominent projection of the anterior border of the tibia should be removed with the saw. (*See* page 624.)

The posterior tibial nerve should be dissected out.

The position of three principal arteries divided has been already mentioned.

Comment.—Both of these operations are excellent. The bones are well covered; the cicatrix is transverse, is upon the anterior aspect of the stump, and is well removed from pressure.

The posterior flap in Hey's amputation is shorter than in Lee's operation. In the former its length is equal to a third of the circumference of the limb; in the latter, to one-half. Provided that the conditions are the same, it will be seen that the second operation involves a greater sacrifice of parts than the first; in other words, Hey's amputation can be performed lower down.

The procedure advised by Lee is well adapted for very muscular limbs, and for cases where the deep muscles of the calf have become matted together or damaged by disease or injury.

Hey's operation is, on the other hand, well suited to the majority of cases, and especially to limbs of moderate or scanty muscular development.

Of the two operations, Lee's is undoubtedly the more easy to perform.

III. Amputation at the "Place of Election"

Anatomical Points.—The term "place of election" refers to the spot at which the bones are divided. This point is about a hand's breadth below the knee-joint and is about, or a little above, the great nutrient foramen of the tibia. The tibia is here still of good size, the cancellous tissue is considerable, but the medullary canal has commenced.

The skin covering the upper third of the leg is a little coarse, is not very mobile, and does not retract so extensively when divided as it does lower down in the limb.

A transverse section of the leg at the "place of election" shows

that the main muscular masses on the antero-external aspect belong to the tibialis anticus and the peroneus longus. The extensor communis digitorum is still a very small muscle. The peroneus brevis and the extensor longus pollicis do not reach the saw-line, but are found in an external flap.

At the back of the limb the gastrocnemius forms a very large mass of muscle—so large as to be nearly equal to the rest of the muscular tissue which lies behind the bones and interosseous membrane.

The soleus is—at this level—divided at about its largest part. The tibialis posticus is of fair size ; the flexor longus digitorum appears as a mere muscular fragment. The flexor longus pollicis lies below the level of the "place of election." The lowest fibres of the popliteus are divided in the section as they adhere to the posterior surface ot the tibia.

In separating or "dissecting up" a flap, it must be observed that the only muscles free are the gastrocnemius and plantaris. All the others are attached to the bones or interosseous membrane.

The anterior tibial artery at the present level lies deeply upon the face of the interosseous membrane, and close to the fibula. The anterior tibial nerve is to its outer side.

The posterior tibial and peroneal arteries are found lying upon the tibialis posticus and occupying the same level, the latter vessel having but just arisen from the trunk. These vessels are located about midway between the two bones.

The posterior tibial nerve is very close to the artery of the same name, but is placed just behind it and to its inner side.

The following are the methods described :—

1. Large external flap (Farabeuf's operation).
2. Circular method.
3. Equal lateral flaps.
4. Large posterior flap.

1. **Amputation by Large External Flap** (*Farabeuf's Operation*).—An amputation in this part of the leg by an external flap has been devised and carried out by Sédillot and others.

Farabeuf has, however, so far modified the operation that he has practically designed a new procedure. He has pointed

out the importance of preserving the anterior tibial artery in the whole length of the external flap, and has shown that if this flap be cut by transfixion the vessel cannot escape damage.

The present method may claim to be a very substantial improvement upon previous operations, and to form a valuable addition to the resources of the surgeon.

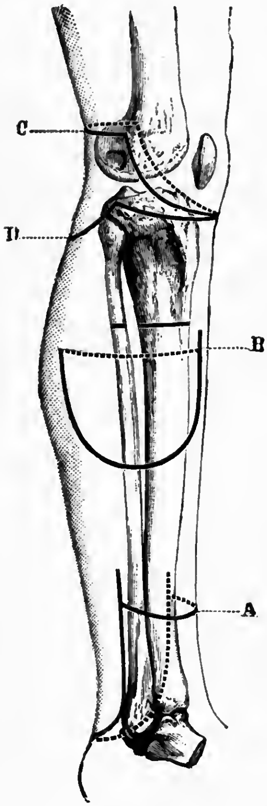

FIG. 414.—A, Amputation of lower part of leg by long posterior flap; B, Amputation at the "place of election" by large external flap (Farabeuf's operation); C, Carden's amputation; D, Lister's modification of the same.

Instruments. — An amputating-knife with a blade from five to six inches in length. A stout scalpel. An amputating-saw. A periosteal elevator. Retractors. Six pressure forceps. Artery and dissecting forceps. Scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the edge of the table. The sound limb is secured out of the range of the operation.

In operating upon the right leg, the surgeon stands throughout on the outer side of the limb. In amputating the left leg, he should stand at the end of the limb, and a little to the outer side of it, while making the preliminary skin incisions. While dissecting up the flap and completing the operation he should stand to the inner side of the limb.

One assistant is placed at the end of the limb, to manipulate the foot and leg. The second assistant stands upon the opposite side of the limb to the surgeon, whom he faces.

Operation. — The external flap is U-shaped. Its length is equal to that of the diameter of the limb at the level of the future saw-line —i.e. is equivalent to one-third of the circumference of the leg at the same level (Fig. 414, B).

The anterior limb of the U is commenced opposite to the

saw-line, and in passing down the leg runs parallel with and just to the inner side of the anterior border of the tibia.

The posterior limb of the **U** follows a line on the back of the calf diametrically opposite to the anterior limb. The posterior incision ends, however, above, at a point about $1\frac{1}{2}$ inches below the commencement of the anterior limb of the **U**.

(1) The operation is commenced by marking out the external flap by a skin incision.

In the case of both the right and the left leg, the knee should be flexed and the limb turned upon its inner side—i.e. so turned that its outer aspect is well exposed to the surgeon. The position of the operator while making the skin incisions has been alluded to. On the right side the incision may be commenced in front, and may be completed in one sweep, the anterior wound being thus made from above downwards and the posterior from below upwards. In the case of the left limb, both of the vertical incisions can be more conveniently made by cutting from above downwards, and can be subsequently joined by the terminal curved incision.

(2) The next step in the operation is to free the skin along the whole length of the incision, so that it may retract. The integuments are merely freed, not dissected up.

(3) The limb being turned outwards, the knife is passed across the inner side of the leg, from the upper end of the posterior incision to a point on the anterior cut about $1\frac{1}{2}$ inch below its commencement (Fig. 414, B). This incision is slightly curved, and involves the skin only. The integuments are lightly freed along the line of incision.

(4) The limb being again turned with its inner surface downwards, the operator proceeds to dissect up the great flap, which should contain all the soft parts down to the bones.

The flap is separated along the anterior limb of the **U** incision by cutting from above downwards down to the bone along the outer side of the anterior border of the tibia. The fingers of the left hand are thrust into the gap so made, and the tibialis anticus is separated from the bone. When the muscle is sufficiently separated, it is cut obliquely from above downwards and outwards, so that the section of the muscle will be thin when the margin of the skin is reached (Fig. 415).

The whole of the soft parts involved in the external flap are dissected up from the bones and interosseous membrane. In effecting this the finger and the handle of the scalpel are used more freely than the knife. The muscles should be cut obliquely at their lower extremities, so that the section of muscle close to the free margin of the skin—i.e. at the bend of the **U**—shall be quite thin. The anterior tibial artery is divided at the free end of the flap in making one of these oblique sections of the muscles (Fig. 416).

In dissecting up the soft parts, great care must be taken not to dissect up the flap too far. If this be done, it is possible

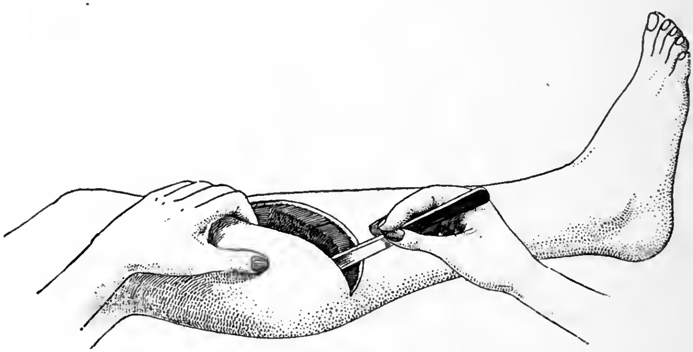

FIG. 415.—MODE OF CUTTING THE FLAP IN THE AMPUTATION AT THE "PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

to reach the spot where the anterior tibial artery is piercing the interosseous membrane, and actually to divide the vessel at that spot.

The future of the operation depends upon the integrity of this artery.

(5) The soft parts included in the small inner flap may now be cut by transfixion at the level of the retracted skin. The muscular tissue so divided must be in the next place separated from the bones up to the level of the saw-line. The bones and interosseous membrane should be bared. The retractors are now applied and the bones sawn through.

(6) The manner in which *the bones are sawn* is of some importance, especially as the prominent anterior border of the tibia is apt to project into the anterior wound when the flaps

have been adjusted. The remarks now to be made apply to all amputations in this region.

The interosseous membrane having been incised, the periosteum covering the tibia is divided by a circular cut. This circular cut is joined from above by two lateral vertical incisions through the investing membrane. The two flaps—anterior and posterior—of periosteum thus marked out should be separated from the bone by an elevator. If preferred, these flaps may be dissected up from the bone with the deepest layers of muscle; or, on the other hand, the periosteum on the posterior surface of the tibia may be ignored, and only the anterior segment preserved. Some surgeons strip up the periosteum from the fibula also.

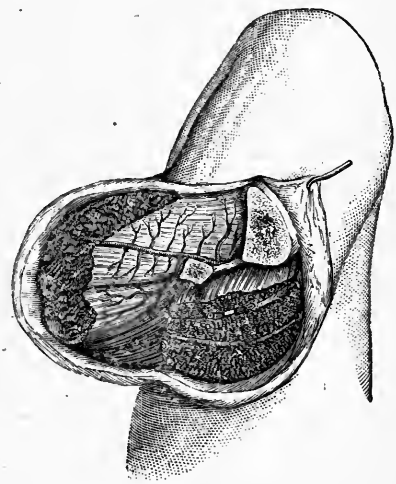

FIG. 416.—APPEARANCE OF THE STUMP AFTER THE AMPUTATION OF THE LEG AT THE "PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

The periosteum is retracted to a point just above the saw-line. The surgeon stands in the same position—i.e. to the outer side of the right leg and to the inner side of the left—and divides the fibula first. The limb is still so placed that the external surface is uppermost. In sawing the left fibula, the point of the saw is directed downwards, towards the floor. In dividing the right bone, the point of the instrument is directed upwards, towards the ceiling. The fibula should be divided about 1 cm. above the tibia, and the saw should pass obliquely from above downwards and inwards. The saw is now entered upon the inner surface of the tibia, above the level at which the bone is to be divided. The instrument is made to cut downwards and out wards for a certain distance. The transverse saw-cut is now made from before backwards, with the result that the whole bone is divided, the piece marked out by the first saw-incision drops off, and the tibia presents a sloping surface on its inner side.

This method of dividing the bones is adapted to the amputations by external flap or by two lateral flaps.

In the case of amputation by antero-posterior flaps or by the circular method, the fibula may be cut at the same level as the tibia, and the anterior margin of the tibia should then be removed by a sloping saw-cut, the instrument being applied in the manner just detailed.

The periosteal flap or flaps having been adjusted over the divided bone, and any deep sutures having been inserted, the operation is completed by closing the surface wound.

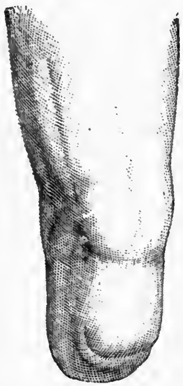

FIG. 416A.—STUMP RESULTING FROM AMPUTATION OF THE LEG AT THE "PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

Hæmorrhage.—The anterior tibial artery is divided at the free end of the external flap. The posterior tibial and peroneal vessels are cut close together, and lie on the same plane upon the face of the inner flap. (*See* page 621 and Fig. 416.)

Several muscular branches will require ligature, notably the sural arteries connected with the gastrocnemius muscle, and the large branch from the posterior tibial artery to the soleus. The nutrient artery of the tibia will be divided at or about its entrance into the bone.

Comment.—An excellent stump results from this operation. The cicatrix comes upon its inner side and is well removed from pressure. The bones are admirably covered, and, if the operation be carefully carried out, the vitality of the great flap is ensured (Fig. 416A).

We believe this to be the best operation for this segment of the leg.

The stump that results is sufficiently long to allow of such an artificial leg being worn as will still permit the movements of the knee to be executed.

In selecting a method of amputation at this level, considerable weight must attach to the intention of the surgeon with regard to the artificial support that is to be worn.

If the use of the knee-joint is to be retained, then a stump must be fashioned that can bear pressure upon its extremity.

If, on the other hand, the knee-joint is to be kept permanently flexed, and the weight of the body is to be borne upon the tuberosity and tubercle of the bent tibia, then the coverings of the stump and the position of the cicatrix are matters of comparatively little moment.

The operation next described involves a terminal cicatrix and a not too well-covered tibia. It is, however, a convenient and sound procedure if the patient is to wear a peg-leg or box-leg, and is to surrender the use of the knee-joint.

2. **Amputation by the Circular Method.** —The same instruments are required as in the last operation. The position of the surgeon and his assistants is the same, with the exception that the operator, in dealing with the left limb, stands throughout on the inner side of the leg.

The circular skin-incision should be made at a distance below the saw-line equal to one-half of the diameter of the limb at that line (Fig. 412, C). This applies to the position of the incision when retraction of the skin has been allowed for.

For example: suppose the circumference of the limb at the saw-line to be 15 inches, the diameter of the limb will be represented by 5 inches and the half-diameter by 2½ inches, or about 6 cm. Retraction of the skin in this part of the limb is not considerable. To allow for it, the circular mark in the skin might be commenced about 3½ inches, or 9 cm., below the saw-line.

The posterior segment of the circular incision should be a little higher than the anterior segment (Fig. 412, C). The tissues at the back of the leg—notably the superficial flexors—retract more readily than do the soft parts upon the front of the limb. If the circular incision be quite horizontal, too much skin will be found in what may be termed the posterior flap.

Operation.—(1) The limb being extended, the circular skin-incision is made, the assistant manipulating the limb the while. The skin is lightly freed all round along the line of the incision.

(2) The skin at the anterior aspect of the limb is separated from the soft parts, and is turned up as a cuff until the soft parts are exposed at the same level all round the limb. At the sides and at the posterior aspect of the leg the skin—which has here merely undergone its natural retraction—is not disturbed.

(3) The knee is now flexed and the leg turned outwards—i.e. with its outer surface directed downwards. The calf being well exposed, the gastrocnemius muscle is separated from the deep flexors with the

fingers, and is divided transversely at the level of the retracted skin.

(4) The integuments all round are now retracted as high as possible, the gastrocnemius muscle being separated up with the skin at the posterior part of the leg.

This retraction and separation of the skin should not reach so high as the future saw-line.

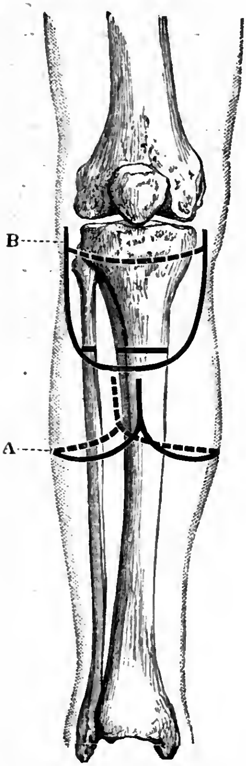

FIG. 417.—A, Amputation at the "place of election" by lateral flaps; B, Disarticulation at the knee by long anterior flap.

(5) The soft parts are now divided transversely a little below the saw-section. The division is commenced in front, and the limb is rotated from side to side or elevated by the assistant as the surgeon requires. These soft parts are now separated all round from the bones and the interosseous membrane, and the separation is carried to a point a little above the saw-line.

It is a good practice to divide the periosteum of the tibia—and possibly also of the fibula—horizontally a little below the future saw-cut, and to separate the periosteum from the bones, together with the soft parts immediately covering them.

To effect this the interosseous membrane must be well divided, and the periosteum be cut laterally, so that it may be peeled off in flaps.

(6) Retractors having been applied, the tibia and fibula must now be sawn in the manner described on page 626.

Deep sutures having been introduced, and the flaps of periosteum adjusted, the operation is completed in the usual way.

Comment.—A good, well-rounded stump results from this method. It is not adapted to withstand much direct pressure, since the scar is terminal. If the weight is to be borne upon the bent tibia, then the stump is free from reproach.

The value of the circular amputation in this section of the lower limb has been already discussed (page 605).

3. **Amputation by Equal Lateral Flaps.**—The general shape and position of the flaps are shown in Fig. 417, A. The flaps are

semilunar in outline. The anterior median incision is commenced some 2 cm. below the future saw-line, and is carried vertically downwards just to the outer side of the crest or anterior border of the tibia. The posterior incision is commenced on the back of the leg, at a point diametrically opposite to the commencement of the anterior incision.

In length each flap should slightly exceed the half-diameter of the limb at the saw-line, retraction being allowed for.

Thus, if the half-diameter be 2½ inches, or 6 cm., the lowest curve of each flap may reach to a point 3½ inches, or 9 cm., below the saw-line. When the skin has retracted, each flap will be found to be about 2½ inches in length.

The flaps are dissected up as skin-flaps.

A little way below the saw-line the soft parts of the limb are divided transversely down to the bones. They are then separated from the bones, and the operation is completed as in amputation by the circular method.

This operation is merely a modification of the circular amputation. It is easier to perform. The cicatrix is terminal, and is antero-posterior instead of being transverse.

4. **Amputation by a Large Posterior Flap,** as described in the operation upon the middle of the leg (page 616), has been performed in this part of the limb.

5. **Teale's Amputation** (page 613) has also been carried out at this level.

It will be seen that these procedures, especially the latter, involve the cutting of very large flaps, without corresponding advantage.

After-treatment of Amputations of the Leg.—The stump should not be covered by the bed-clothes, and the limb should be slightly raised upon a firm pillow, with the knee a little bent.

In the case of the supramalleolar amputations, and in the amputations of the leg by a large posterior flap, the limb should be supported upon a back-splint. This splint should be applied in the manner already indicated (page 484). Care must be taken that the wound is free from pressure. In some of the circular amputations also the splint may be conveniently applied.

In the other operations the limb may be lightly secured to the pillow, the extremity of the stump projecting some little way beyond the end of the support, as in Teale's operation above the

ankle. The same plan may be adopted after Farabeuf's amputation at the place of election.

The sutures should not be removed too soon, especially in cases where a posterior muscular flap has been formed, or where a single flap from the outer side of the limb has been fashioned, or where the circular method has been carried out. After the sutures are removed the flaps may possibly need to be supported by strapping.

If drainage-tubes are required, they should be introduced for a short distance only, at the angle of the wound. A tube should never be inserted through the depths of the wound from one side of the stump to the other. It should be removed at the earliest possible date.

CHAPTER X

DISARTICULATION AT THE KNEE-JOINT

This operation appears to have been introduced into modern practice by Velpeau in 1830, and to have been first performed in England in 1857 by Mr. S. Lane (*Lancet*, vol. ii., 1857).

It was not received with great favour, and after a while fell into disrepute. Not a few surgeons, indeed, considered that the operation was unjustifiable and should never be performed.

The objections urged against it were these: The synovial pouches which were left upon the stump suppurated and formed recesses for the accumulation of pus. The bursæ about the joint gave similar trouble. Pus spread dangerously among the loose tissues of the ham. The cartilage covering the condyles of the femur was apt to become necrosed and to be exfoliated by a very tedious process. The bone not infrequently became involved. The flaps formed were disposed to slough, and while this applied especially to the large anterior flap, it could also be frequently urged against a large posterior flap. Even if the patient survived the dangers of extensive and prolonged suppuration, and reached the time when the wound had healed, the resulting stump was still unsatisfactory. It was as a rule tender, disposed to ulcerate, and unable to bear pressure.

The mortality of the operation was considerable. Panas, in a statistical table (*Dict. de Méd. et Chir. Prat.*, art. "Genou"), showed that a recovery occurred in only 33 cases out of a total of 137 operations.

Since the introduction of antiseptic methods for treating wounds, and of certain improvements in the details of the operation, the whole aspect of the question has become altered, and none of the above-mentioned objections now holds good.

Flaps can now be made that do not, under ordinary conditions, slough. The operation wound will heal up by first intention in the large majority of cases. Suppurative inflam-

mation in the relics of the synovial membrane is no longer to be feared, and exfoliation of the cartilage is either not met with at all or occurs as a quite accidental and preventable trouble. The once anxious doubt as to the fate of the articular cartilage no longer disturbs the operator's mind. It has ceased to be necessary further to complicate a serious operation by scraping away synovial membrane and cutting off cartilage. The patient can now bear the weight of his body upon the extremity of the stump.

The mortality has also undergone a substantial improvement. Ashhurst ("Encyclopædia of Surgery," vol. i., 1882) gives the statistics of 794 examples of amputations of various kinds, both through the knee-joint itself and through the femoral condyles. The mortality was about 48 per cent.

Bryant, in an account of 30 disarticulations at the knee-joint, performed by himself between the years 1868 and 1883, demonstrates a mortality of less than 25 per cent. Indeed, among 19 cases of disarticulation for disease, only one death is recorded as directly due to the operation (*Med.-Chir. Trans.*, 1886, vol. lxix., page 163).

This disarticulation has many advantages over the simpler and more brilliant-looking amputations through or above the femoral condyles. There is less shock, and less of the limb is removed. The section of the tissues of the limb is less, and the connective-tissue planes of the thigh are not opened up. Important muscular attachments are left undisturbed, and there is little muscular retraction.

The stump is an excellent one, capable of great mobility and of bearing direct pressure. This is important when it is remembered that very few of the stumps resulting from amputation through the femur will bear direct pressure. Farabeuf, writing upon this point, remarks that, so far as he knows, the stumps left after amputation through the shaft of the femur can never directly transmit the weight of the body. This is not entirely correct. After an amputation just above the condyles (Stokes-Gritti) the patient can almost always bear his weight on the end of the stump.

Before describing individual methods of procedure, it may be said that in every case it is essential that the knee-joint be free from disease. In no instance is it necessary to dissect away

the remains of the synovial membrane, or to attempt its destruction by scraping. The less the cartilage is disturbed the better, and the practice of cutting it away from the bone is unnecessary and harmful.

Both the patella and the semilunar cartilages should be left undisturbed.

By leaving the patella the stump is rendered firmer, and its rotundity is greatly increased. Moreover, the attachments of the quadriceps are not disturbed, and the muscular strength of the stump is considerably increased. On the other hand, by dissecting out the patella much damage is inflicted upon the anterior flap. Not only is it dangerously thinned, but its blood-supply is further curtailed. It has never been shown that any evil has followed the retaining of the patella.

By leaving the semilunar cartilages in contact with the bone, the upper part of the synovial capsule is held down firmly to the condyles of the femur, and the soft parts concerned are kept well in place.

Anatomical Points.—The skin over the front of the knee-joint is dense, coarse, and movable, and well supplied with blood. The subcutaneous tissues are scanty. The skin is most loose in the position of extension. When the joint is flexed, the integuments are drawn tightly over the patella. In dissecting up an anterior skin-flap, therefore, the limb is kept extended.

The vessels supplying the soft parts in front of the joint—the parts forming the large anterior flap—are the anastomotica magna, the four articular branches of the popliteal, and the anterior tibial recurrent. The last-named vessel and the two lower articular arteries are divided when the flap is cut. The most important vessels in the separated flap are those derived from the anastomotica magna.

The interarticular line is easily demonstrated. The crease in the skin which passes transversely across the ham is some way above the line of the knee-joint. The inner condyle of the femur is much more prominent than the external, a point to be borne in mind in fashioning lateral flaps. The tubercle of the tibia and the head of the fibula are nearly upon the same level.

The synovial membrane of the knee-joint extends upwards as a *cul-de-sac,* about one inch above the upper margin of the patella. Above this pouch is a bursa between the femur and the quadriceps tendon. It measures about one inch vertically. This bursa com-

municates with the joint in some seven cases out of ten in children, and in about eight cases out of ten in adults.

The upper third of the patellar ligament is in relation with the synovial membrane.

The lower end of the patella corresponds roughly to the interarticular line, when the knee is extended. To be quite precise, it is just level with the upper margin of the tibia.

The external semilunar cartilage is smaller, rounder, less firmly attached, and more movable than the internal.

At the interarticular line the popliteal artery is descending vertically behind the middle of the joint capsule, upon which it rests. It terminates on a level with the lower part of the tubercle of the tibia. At the level of the knee-joint the popliteal vein is lying behind the artery. The internal popliteal nerve is behind the vein and a little to its outer side. The walls of the vein are so dense and thick that on section the vessel looks almost like an artery. It is very closely adherent to the arterial trunk. The internal saphenous vein passes along the back of the internal condyle.

The upper articular arteries run transversely outwards and inwards just above the femoral condyles. The articular vessels below the knee run respectively just below the inner tuberosity of the tibia and just above the head of the fibula. The superior external and inferior internal arteries are of fair size. The others are quite small.

The large sural arteries arise just above the joint-line.

The following methods are here described :—

1. Disarticulation by lateral flaps (Stephen Smith's operation).
2. Disarticulation by elliptical incision (Bauden's operation).
3. Disarticulation by long anterior flap.

1. **Disarticulation by Lateral Flaps** (*Stephen Smith's Operation*).—This operation, known usually as disarticulation by "lateral hooded flaps," is described in the *American Journal of Medical Sciences*, January, 1870.

The flaps consist of the integuments only, the posterior muscles being divided transversely about the level of the articulation.

Instruments.—An amputating-knife with a blade 5 to 6 inches in length ; a stout scalpel ; six pressure forceps ; artery and dissecting forceps ; retractors, scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the lower margin of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the right leg, to the inner side of the left. One assistant, placed at the extremity of the limb, holds the leg and manipulates it as required. The second assistant stands facing the surgeon, and attends to the flaps, the sponging, etc.

Operation.—The flaps are of somewhat semilunar outline. The incision commences in front, in the median line, about one inch below the tubercle of the tibia. It is carried in a curved manner across the most prominent part of the outer side of the leg, and is then made to slope upwards to reach the middle line at the posterior aspect of the limb. It terminates as a vertical cut opposite the centre of the interarticular line.

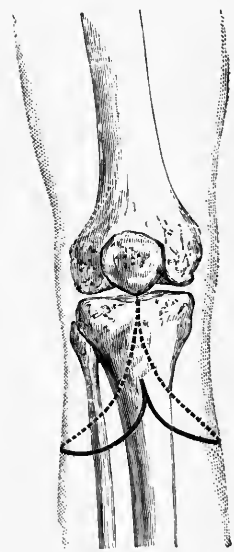

FIG. 418.—STEPHEN SMITH'S DISARTICULATION AT THE KNEE.

A second incision begins at the same point on the front of the limb as the first, and pursues a similar direction across the inner side of the leg, meeting the first incision at the median line upon the posterior aspect of the extremity. The inner flap should be a little fuller than the outer, in order to ensure a sufficient covering for the internal condyle, which is longer and larger than the external.

The outline of the flaps is shown in Fig. 418.

(1) The skin-incisions on both the right and the left leg are more conveniently made by cutting from behind forwards. The knife is entered at the posterior aspect of the limb, at a spot opposite to the centre of the interarticular line, and is drawn forwards, first upon one side of the limb and then upon the other, to reach the point of meeting one inch below the tubercle of the tibia.

While the outer incision is being made the limb is rotated inwards, and vice versa.

The knee-joint should be extended during the cutting of the flaps.

(2) The skin is freed all round, and the two flaps are dissected up. They should include all the soft parts down to the tendons and muscles, which are well laid bare, but are as yet left uncut. The patellar ligament is cut as soon as it is reached, being divided against the tuberosity of the tibia.

The flaps are retracted to the level of the joint-line.

(3) An incision is now made along the extreme upper margin of the tibia. This incision, which is transverse and concerns the anterior and lateral aspects of the bone; divides everything down to the bone, including the ilio-tibial band, the tendons of the sartorius, gracilis, semitendinosus, and biceps muscles, the internal and external lateral ligaments, and, lastly, the coronary ligaments attaching the semilunar cartilages. The knife, indeed, enters the joint between the upper surface of the tibia and these cartilages, and it is in this manner that the articulation is opened. In dividing the coronary ligaments the knife should be entered at the sides of the joint and not in front.

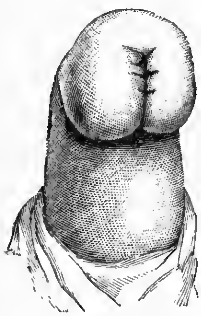

FIG. 419.—THE STUMP AFTER STEPHEN SMITH'S AMPUTATION AT THE KNEE-JOINT. (*After Bryant.*)

The knee is now flexed, and the two crucial ligaments are carefully divided from before backwards.

(4) Nothing remains but to divide by a vigorous transverse cut the soft parts still connecting the leg with the thigh, viz. the posterior ligament of the joint, the popliteal vessels and nerves, the popliteus and gastrocnemius muscles, and the semimembranosus or other undivided tendon of the ham.

Before making this final incision, the assistant who is retracting the flaps should compress the popliteal artery against the lower end of the femur.

Bryant advises that the condyloid origins of the gastrocnemius should be removed, but there appears to be no need for this step.

Hæmorrhage.—The popliteal artery and vein are the only vessels of any size requiring ligature. Ligatures will probably be needed for the sural arteries, the azygos artery, for branches

of the superior articular vessels (especially on the outer side), and for the superficial division of the anastomotica magna (on the inner side of the limb).

Comment.—This operation provides an excellent and complete covering for the condyles of the femur. When the edges of the flaps are brought together, the wound looks directly downwards as the patient lies in bed. The stump therefore is admirably provided for in the matter of drainage.

A very serviceable extremity results. The cicatrix lies in an antero-posterior direction between the condyles, and in process of time occupies the intercondyloid notch. Into this depression it sinks, and the prominent condyles serve effectually to protect it from pressure. It will be seen, moreover, that the scar is in time drawn towards the posterior aspect of the limb, and is thus further protected from pressure when an artificial leg is worn (Fig. 419).

2. **Disarticulation by Elliptical Incision** (*Bauden's Operation*).—The *instruments* required and the *position* of the patient and of the surgeon are the same as in the previous operation.

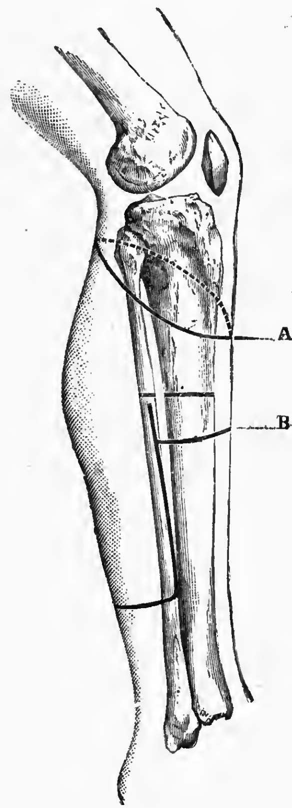

FIG. 420.—A, Disarticulation at the knee by the elliptical method (Bauden's operation); B, Henry Lee's amputation of the leg.

The interarticular line having been made out, the antero-posterior diameter of the limb at this line is estimated. The elliptical incision is so planned that its lowest part crosses the crest of the tibia at a distance below the joint-line equal to the antero-posterior diameter of the limb. The highest part of the ellipse reaches the median line posteriorly at a distance of half a diameter below the same line. The incision is inclined at an angle of about 30 degrees (Fig. 420, A).

The incision is carried through the integuments, which are then well freed along the whole extent of the wound.

The skin on the anterior aspect of the limb is turned up in the form of a cuff, while that on the posterior side of the leg is displaced upwards by gliding merely.

By the employment of these two methods the integuments are retracted as far as the patella, the knee-joint being kept extended during the process.

The limb is now flexed a little, the patellar ligament is divided, and the articulation is entered by passing the knife between the semilunar cartilages and the head of the tibia, as in the operation last described.

Both the patella and the semilunar cartilages are preserved.

The ligaments having been divided as already described, the soft parts at the back of the joint are severed by a circular cut with the knife, made from before backwards.

The cicatrix resulting from this operation is transverse, and is placed upon the posterior aspect of the limb. A very excellent stump is obtained.

3. **Disarticulation by Long Anterior Flap.**—This is sometimes known as Pollock's operation, the procedure having been elaborated by that surgeon.

Both of the flaps are skin-flaps, and are somewhat rectangular in outline (Fig. 417, B).

The following is the description given by Mr. Pollock (*Med.-Chir. Trans.*, vol. liii., 1870) :—" I feel for the interval between the edges of the outer condyle and head of the tibia, and commence my incision at that point and immediately behind the edge of the ham-string muscle as it crosses that space. I take especial care never to commence my incision higher than the margin of the condyle. The incision should be carried perpendicularly downwards on the side of the leg till nearly five inches below the lower edge of the patella, then gradually brought across the front of the leg, and when crossing the tibia should be quite five inches below the patella, then carried up the inner side to a point corresponding exactly to that from which the incision commenced. I usually make the posterior flap by cutting from without inwards ; it should not be too short, and should consist merely of integument. As soon as the flaps are completed, all the structures round the joint should be divided at right angles with the limb." The patella is left.

The resulting cicatrix is transverse, and is placed upon the posterior aspect of the stump.

Comment.—Other methods of disarticulating at the knee-joint include the operation by equal anterior and posterior flaps, and the operation by cutting a single long posterior flap from the soft parts of the calf. The three most noteworthy methods, however, are those just given.

Of these the best is certainly that first described—the disarticulation by lateral flaps. This operation is simple and is easily performed ; it makes no great demands upon the tissues on any one side of the limb ; it leaves a wound well adapted for satisfactory drainage, and an admirable stump with a well-protected cicatrix.

Most of these advantages can be claimed for the second operation—that by the elliptical incision. In this procedure no great demands are made upon the soft parts of the leg, and the wound admits of satisfactory drainage. The operation, however, is not so easy to perform ; the cicatrix is transverse, and is consequently not so well protected as it is in Stephen Smith's operation, where it sinks into the intercondyloid notch. By both these operations an excellent covering is provided for the condyles.

The operation by the long anterior flap was for many years the chief method employed by English surgeons for amputation at the knee-joint. The method, however, does not compare favourably with the two operations already alluded to. The long anterior flap does not, in the first place, provide so good a covering for the condyles. In the second instance, it is of so great a length, and so thin in substance, that it is of necessity ill-nourished and liable to slough. This circumstance offers the most serious objection to the operation.

The operation by the long anterior flap makes, moreover, a great demand upon one particular side of the limb, the wound is not so well adapted for spontaneous drainage, and in the resulting stump the cicatrix is not quite so favourably placed.

The long posterior flap has nothing to recommend it. The flap made is heavy and cumbrous, and undergoes considerable retraction.

The operation may be entertained in cases of localised destruction of the integuments of the front of the leg.

After-Treatment of Amputations at the Knee-Joint.—The stump should not be covered up by the bed-clothes. The limb should be slightly raised upon a firm pillow. To this support the thigh should be lightly secured—in such a way that the extremity of the stump projects a little beyond the end of the pillow or cushion.

In none of the operations named is a splint required.

Excellent drainage is offered by the position of the wound, and drainage-tubes should only be used in exceptional cases. In no circumstances should a tube be passed right across the wound from one end to the other. There is often considerable strain upon the sutures, which should not be removed too soon. Silkworm-gut sutures may be left in for ten, or even fourteen, days if necessary.

CHAPTER XI

AMPUTATIONS OF THE THIGH

1. Through the Condyles

In this operation the femur is divided at the bases of the condyles, about the level of the tubercle for the insertion of the adductor magnus tendon, or a little above that spot. The patella is removed.

Anatomical Points.—The femur at the level named is still of considerable width, and is composed of cancellous tissue. The medullary canal does not commence until the narrower part of the shaft of the bone is reached, some inches above the interarticular line.

The trochlear surface of the femur reaches much higher up on the external than on the internal condyle. The former process is somewhat more prominent anteriorly.

A horizontal saw-cut made at the level of the adductor magnus tubercle will remove the whole of the bone carrying articular cartilage. Such a cut, indeed, just touches the upper limit of the cartilage. This saw-line also corresponds to the epiphysial line.

The lower epiphysis does not join the shaft until the age of twenty years. In young subjects the saw should be passed, if possible, below the epiphysial line.

The only muscular fibres attached about the bases of the condyles belong to the gastrocnemius and plantaris muscles, and to the lower part possibly of the adductor magnus.

At the level of the saw-line the gracilis and semitendinosus are wholly tendinous ; the sartorius is still muscular, and the biceps and semimembranosus are still in great part muscular. The popliteus arises below the level of the saw-line.

The patella is removed in the operation, and as the important fibrous expansions on either side of it, belonging to the vasti, are divided, the quadriceps is set free, and considerable retraction of the fibres of that muscular mass must be anticipated.

The synovial pouch, extending upwards between the quadriceps and the femur, has been alluded to (page 633).

At the level of the saw-line the popliteal artery is resting obliquely against the inner segment of the bone. The vein lies behind it and to its outer side. The nerve is quite to its outer side.

Instruments.—Amputating-knife, five to six inches in length as regards its blade. Stout scalpel. Butcher's saw. Retractors. Six pressure forceps. Artery and dissecting forceps; scissors, etc. Lion forceps may be required.

Position.—The position of the surgeon and of his assistants is the same as in the last series of operations (page 635).

Three **methods** will be described :—

1. Carden's operation.
2. Modifications of Carden's operation.
3. Gritti's operation.

1. **Carden's Operation.**—Mr. Richard Carden's operation was first described in the *British Medical Journal* for April, 1864, although that surgeon had carried out the method now known by his name since 1846.

" This operation," he writes, " consists in reflecting a rounded or semi-oval flap of skin and fat from the front of the joint, dividing everything else straight down to the bone, and sawing the bone slightly above the plane of the muscles, thus forming a flat-faced stump with a bonnet of integument to fall over it."

(1) The incision is commenced at the most prominent part of the tuberosity of one condyle, and ends at a corresponding point on the other condyle. The cut over the front of the limb sweeps with an easy curve between these two points, and crosses the median line about the middle of the patellar ligament. The posterior incision is quite horizontal (Fig. 414, C).

The anterior cut is made first. The points of starting and ending may be marked by the thumb and forefinger. The knee-joint is a little flexed as this incision is being made. In the right limb it is commenced on the inner side, and in the left extremity on the outer side. The assistant rotates the limb as the knife passes across it. The posterior incision is made by one single transverse sweep. Both incisions

should involve at first only the skin and the subcutaneous tissue.

(2) The limb being extended, the anterior flap is dissected up, containing all the soft parts down to the patella and the capsule of the joint. The posterior "flap" may be a little freed and allowed to glide up, in order to aid the separation of the anterior flap.

(3) The knee being flexed, the joint is opened by cutting through the quadriceps tendon just above the patella. That bone is seized by the surgeon, and the anterior capsule divided on either side. The crucial and lateral ligaments are cut. With one vigorous sweep of the knife the tissues at the posterior aspect of the limb are then divided down to the bone at the level of the hinder skin-incision. A few touches with the knife serve entirely to separate the leg.

(4) The soft parts are now retracted so as to clear the bone for the passage of the saw. In dividing the femur the saw must be kept parallel to the articular surface and perpendicular to the shaft. In young subjects regard must be had to the epiphysial line.

Hæmorrhage.—The popliteal artery is divided close to the bone at its inner aspect. Some muscular branches may require ligature. On the cut surface of the posterior flap will be found the two superior articular branches from the popliteal (divided close to the femur) and the anastomotica magna (on the inner side). Branches of the latter vessel and of the descending portion of the external circumflex may require to be secured in the margins of the anterior flap.

2. **Modifications of Carden's Operation.**—(*a*) *Lord Lister* ("Holmes's System of Surgery," vol. iii., 1883) writes as follows :—

"I found it advantageous to form a short posterior skin-flap, both for the sake of co-aptation of the cutaneous margins without puckering, and as a useful addition to the covering for the end of the stump.

"The surgeon first cuts transversely across the front of the limb, from side to side, at the level of the anterior tuberosity of the tibia, and joins the horns of this incision posteriorly by carrying the knife at an angle of forty-five degrees to the axis

of the leg through the skin and fat (Fig. 414, D). The limb being elevated, he dissects up the posterior skin-flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue, and dividing the hamstrings as soon as they are exposed; and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks his knife through the insertion of the quadriceps extensor, and having cleared the bone immediately above the articular cartilage, and holding the limb horizontal, he applies the saw vertically and at the same time transversely to the axis of the limb (not of the bone), so as to ensure a horizontal surface for the patient to rest on."

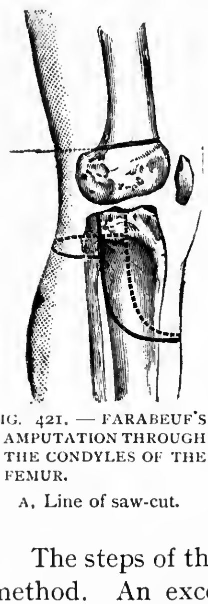

FIG. 421. — FARABEUF'S AMPUTATION THROUGH THE CONDYLES OF THE FEMUR.

A, Line of saw-cut.

(*b*) *Farabeuf's* modification of Carden's procedure is practically a new operation. The femur is divided at the same level, but different flaps are cut. The anterior flap exceeds in length the antero-posterior diameter of the limb at the saw-line by about an inch. The posterior flap is equal to half that diameter. The lateral incisions which mark out the anterior flap commence just below the joint-line (Fig. 421). The outer cut descends on the fibula, the inner is placed about two inches behind the inner edge of the tibia. The anterior flap, therefore, will occupy more than half the circumference of the limb.

The steps of the operation are precisely the same as in Carden's method. An excellent stump is provided.

The cicatrix in all these operations is found upon the posterior aspect of the limb.

3. **Gritti's Operation.**—This operation, designed by Rocco Gritti, of Milan, in 1857 (*Annali Universali di Medicina*, Milan, 1857), is an application of the osteo-plastic method of Pirogoff to amputations at the knee.

The patella is retained, but its articular surface is removed with the saw. To effect this the bone has practically to be bisected. The femur is divided transversely at the upper edge

of the articular surface—i.e. about the level of the adductor magnus tubercle.

The two sawn surfaces of bone are brought together, and it is presumed that they will unite, that the patella will form the summit of the stump, and that upon it the weight of the body will be borne.

Operation.—The position of the patient, and of the surgeon and his assistants, is the same as in the preceding operations. In addition to the instruments enumerated, the following are required: A fine metacarpal saw, or small Butcher's saw, for the patella; a pair of lion forceps to hold the patella; cutting pliers, in the event of the articular surface of the patella being removed by cutting rather than by the saw; a bone-drill; stout catgut or wire sutures or pegs for the bones.

An anterior flap is made which commences on either side at the level of the tuberosities of the femoral condyles, and which reaches below to the lowest part of the tubercle of the tibia. This flap is rectangular in outline (Fig. 412, D). The skin at the back of the limb is divided transversely or by an incision which is inclined a little downwards. The general steps of the operation are the same as those already given.

The anterior flap is dissected up as soon as the ligamentum patellæ has been divided at its insertion. This flap is turned up with the patella in it undisturbed. The knee-joint having been opened, disarticulation is effected, and the soft parts at the back of the limb are divided by a sweep of the knife. The lower end of the femur is removed with the saw. Finally, the articular surface of the patella is sawn off or removed by cutting pliers.

The parts are finally adjusted when all the bleeding points have been secured. The cicatrix is entirely posterior.

Gritti appears to have employed no especial means for keeping the two bony surfaces in close contact.

The sawing of the patella presents the only difficult step in the operation. The bone has—as it were—to be split.

Whilst the surgeon will probably choose his own way of effecting this, it may be said that the method which involves the least injury to the tissues is the following: The surgeon reflects the flap, and with a scalpel incises the soft parts round the articular edge of the patella, so as to make a way for the saw.

Grasping the patella between his left index and thumb, the surgeon can then remove a layer of bone and cartilage by means of a narrow (Butcher's or Farabeuf's) saw. This avoids all rough handling with bone-forceps, etc.

There is certainly no advantage to be gained by removing the cartilage with cutting pliers.

Sir W. Stokes has considerably modified this operation. He points out that there is always a difficulty in keeping the two bony surfaces together. These surfaces differ very materially in size, and the fragment of the patella is very apt to slide to and fro upon the wide surface of the divided condyles.

Moreover, so low down is the femur sawn that it is sometimes difficult to bring the patella into easy contact with it. The fragment of the knee-cap may have to be forced into position. The strain thus placed upon the quadriceps is soon removed by the contraction of that muscle, and the patella is drawn forwards and made to assume an oblique position. It then becomes a veritable foreign body in the stump, and has led to caries of the bones and to a tender and painful extremity. To overcome these objections Stokes divides the femur higher up—viz. at a point from half to three-quarters of an inch above the condyles. The section of the bone at this level is more nearly equal in size to that of the divided patella. At the same time it is not sufficiently high up to expose the medullary canal.

Different flaps are cut. The anterior flap is oval, and reaches from a point one inch above either condyle to a point just below the tubercle of the tibia. A posterior flap is formed, which is at least one-third of the length of the anterior flap.

The bones may be kept in position either by closely suturing the soft parts above the patella to the posterior flap, or by drilling the bones and securing them by wire or catgut sutures or by pegs.

A distinction between Gritti's operation and Stokes's modification of the same has been made by describing the former as a transcondyloid amputation, and the latter as a supracondyloid.

Comment.—In commenting upon these various procedures it may, in the first place, be said that the best method of removing the limb about the knee is undoubtedly by disarticulation. The advantages of this procedure, when compared with amputations

through the limb immediately above the knee, have been already dealt with (page 632). When comparing the operations through the condyles (just described) with amputations through the shaft of the femur, considerable advantages must be allowed to attend the former procedures.

In the first place, the stump left after an amputation through the femoral shaft will not bear direct pressure, the weight of the body cannot be borne upon it, and the artificial limb worn must take its main support from the pelvis.

In the amputations through the condyles, a broad section of bone is left in the stump, and the skin covering the extremity is accustomed to bear pressure (as in kneeling). It follows that the stumps left after such operations can bear direct pressure, and the importance of this fact cannot well be exaggerated.

The other advantages to be claimed for these condylar operations, when compared with amputations through the shaft, are these: The limb is removed lower down, there is less shock, and the medullary canal is not opened up. Muscular attachments are but little disturbed, and such muscles as are divided are cut in their tendinous parts, and not where the tissues are thick and vascular. The function of the adductors is scarcely at all disturbed. There is little muscular retraction, and but slight disposition for the end of the bone to protrude, or for a conical stump to result. Both these complications are not uncommon after amputations through the lower part of the thigh.

Of the methods described, Carden's operation is probably the best. If, however, the flaps are cut precisely as Carden directed, they will often be found to provide but a scanty covering for the bones. This operation, when performed upon the cadaver, appears to be in every respect admirable, but it is a little less satisfactory on the living. A flap cut from the front of the knee in the living subject will retract one-third of its length after it has been separated from the deeper parts. Thus a flap six inches in length will shorten to one of four inches.

Either of the two modifications of Carden's operation is to be recommended in the place of the original procedure. They both give admirable results.

Considerable differences of opinion have been expressed as to the value of Gritti's operation. There is no evidence to show

that the presence of the patella in the stump adds very greatly to its usefulness, or improves its capacity for bearing pressure. Against the operation as described by Gritti the objections already detailed in the description of the procedure must be urged. These objections are met by Stokes's modification of the method. Excellent results have been obtained by Stokes's operation. One great point in its favour depends upon the circumstance that the soft parts in the anterior flap are but little disturbed, and that the risks of sloughing of that flap are reduced to a minimum.

The importance of retaining the attachment of the quadriceps has perhaps been a little exaggerated. The wasting of that muscle after Stokes's operation would appear to be as great as after the amputation by Carden's method.

The stump left by a Stokes-Gritti amputation is as a rule almost ideal: it is painless, bears pressure well, and the scar is well protected.

II. Amputation through the Shaft of the Femur

The operations so named concern amputation through the shaft of the femur, and occupy an intermediate position between disarticulation at the hip-joint on the one hand and the supra- or trans-condyloid operations on the other. For the most part they involve a division of the bone at or below its centre. The subtrochanteric amputation is seldom performed.

These operations play a conspicuous part in surgery, being performed for many injuries and diseases of the leg, and notably also for affections of the knee-joint and of the popliteal region.

Practically, every known form of amputation has been carried out in this part of the limb, and nearly every method—excepting that by a large posterior flap—has received a certain degree of support.

The procedures themselves are involved in a very exuberant and complicated nomenclature. Operations in all essential features alike have been separately designed by independent surgeons, and where the names of the authors have been retained no little confusion has resulted.

Recognised methods have been modified in so many ways

that a classification of all known amputations of the thigh becomes exceedingly involved.

No particular advantage, however, would appear to attend the attempt to define the distinctive features of such operations as those of Spence, Sédillot, Benjamin Bell, and O'Halloran, or to retain the names of those distinguished surgeons in association with specific methods.

Considerable differences of opinion exist as to the comparative merits of the various amputations in this region, and many of the statements made by most competent men are not reconcilable.

One surgeon (Stimson), in his account of these operations, makes no mention of the circular amputation, and states that "the superiority of the flap operation (in this part of the limb) is now generally admitted." Another writer (Guérin), dealing with the same region, observes, "L'amputation de la cuisse est le triomphe de la méthode circulaire."

In the account which follows it has only been possible to make a selection from the twenty and more "recognised methods."

Anatomical Points.—The outline of the diaphysis of the femur is well known. The medullary cavity, as a distinct canal, occupies about the middle two-fourths of the shaft of the bone. The nutrient canal is found upon the linea aspera, a little way above the centre of the shaft. The vessel it contains is directed towards the hip.

The skin of the thigh is somewhat coarse and thick upon the outer side of the limb, and is thinner and finer on the inner aspect. It is but loosely attached to the parts beneath, and thus it follows that flaps composed of the integuments contract considerably. The skin is a little more firmly connected with the deeper parts along the groove between the vastus externus and the hamstrings, this being the situation of the outer intermuscular septum.

The whole limb is invested by the dense fascia lata, which is thinnest on the inner aspect of the thigh and thickest externally. On the latter surface of the limb is the ilio-tibial band.

In muscular subjects the outline of the thigh is irregular on section; in stout and non-muscular individuals, and in young children, it is more or less evenly rounded.

The great mass of the muscular tissue of the part has some attachment to the femur. Certain muscles, however—viz. the hamstrings, the gracilis, and the sartorius—are free. Of these the biceps is the

least separate, being connected with the femur below the centre of the bone by means of its "short head." It happens, therefore, that the thigh muscles retract very unequally when divided, retraction being conspicuous upon the posterior and internal aspects of the limb.

In a section through the thigh at its *upper third*—just below the lesser trochanter—the bone is found to be well and evenly covered with muscles in front, behind, and on the inner side. It comes nearest to the skin at the outer aspect of the thigh. The muscular masses are extensive, and a considerable portion of the gluteus maximus comes into the section.

When the limb is divided transversely through the *middle of the femur*, it will be found that the bone is evenly surrounded, and is about the centre of the section. The main muscular masses are formed by the vasti, the crureus, and the adductor magnus. The section of the last-named muscle is nearly equal in extent to that of the three hamstrings taken together at this level. The biceps and semitendinosus are here quite separate. The short head of the biceps is commencing. The adductor longus is small, and the adductor brevis has disappeared. The linea aspera is most prominent at this part of the shaft.

A transverse section at the *lower third*—about a hand's-breadth above the knee—shows that the bone is now nearest to the skin on the anterior aspect of the limb. The great bulk of the muscle tissue is behind the bone. The adductor longus has disappeared; the quadriceps is very much reduced; the biceps and semimembranosus still present large surfaces on section; the semitendinosus is small; the adductor magnus is considerably reduced, and is becoming entirely free of the femur.

The femoral artery ceases at the commencement of the lower fourth of the thigh. In antero-posterior flaps the vessel comes in the anterior flap when above the centre of the limb, and in the posterior when below that point.

At the apex of Scarpa's triangle the femoral vein lies behind the artery; below that spot it is found somewhat on the outer side of that trunk.

The internal saphenous nerve accompanies the artery, lying upon its anterior surface. Care must be taken that it is not included in the ligature when the artery is secured.

The profunda artery terminates at the commencement of the lower third of the thigh. The femoral and profunda veins and the adductor longus are interposed between it and the femoral trunk.

The anastomotica magna arises from the femoral just before it terminates. The superficial branch of the vessel is accompanied to the inner side of the knee by the long saphenous nerve.

The descending branch of the external circumflex artery reaches to the outer side of the knee.

Instruments.—Large amputating-knives. (For the circular operation the blade should be about 7 or 8 inches in length, and for cutting flaps by transfixion about 9 to 10 inches. These measurements refer to the amputation as applied to the average adult limb. In marking out skin-flaps, and in dissecting up the integuments in the circular operation, a stout knife with a broad blade 4 inches in length and a well-rounded point should be used. No attempt should be made to complete the circular amputation with one long knife. In shaping muscular flaps by cutting—as distinguished from transfixion—the stout knife with a four-inch blade should be employed. The same knife may be conveniently used to clear the bone for the saw—e.g. after transfixion flaps have been cut.) A full-sized amputation-saw. A small Butcher's saw, to shape the end of the divided femur. A dozen pressure forceps. Artery and dissecting forceps. Retractors, scissors, needles, etc.

Position.—The patient's buttocks rest upon the end of the table. The sound leg is secured out of the way. Means should be taken to prevent the body from slipping off the table. The surgeon stands to the right of the limb in the case of either extremity. (He will always be able to place himself to the outer side of the right limb; but if there should be any obstacle in the way of his standing to the inner side of the left thigh, it will be found that he can operate from the outer side without greatly increased difficulty.)

One assistant sits beyond the end of the table, to hold and manipulate the limb. A second assistant stands to the surgeon's left (or to his right if the operator be placed to the outer side of the left limb); his duties are to retract the skin (in the circular operation), to grasp the flaps when cut, to apply the retractors, and to hold the stump up while the arteries are being secured. The third assistant stands below the surgeon, and attends to the sponging and the securing of the bleeding points.

The following **methods** of amputating the thigh through the shaft of the femur will be described :—

1. Circular method.
2. Syme's modification of the circular method.
3. By long anterior and short posterior flaps.

The comparative value of these different methods, and their applicability to different portions of the thigh, are considered on pages 657-58.

1. **The Circular Amputation.** — Owing to the unequal manner in which the divided muscles retract, the simple circular operation is not adapted for the thigh. In order to allow for this irregular retraction, the incision must be placed obliquely.

This operation should only be carried out in the lower third of the limb. Farabeuf gives the following directions for the incision :—

On the anterior and outer aspects of the limb the distance between the level of the proposed saw-cut and the incision on the skin should be equal to one-fourth of the circumference of the thigh at the former point. On the hinder and inner aspects of the limb the skin-incision should be made a little less than half this length lower down (Fig. 422, A).

For example : if the circumference of the thigh at the proposed saw-level be 18 inches, the skin-incision in front and on the outer side should be $4\frac{1}{2}$ inches below that level, while on the posterior and inner aspects of the limb it should be $6\frac{1}{4}$ inches below the same point.

Operation.—The proposed incision should be marked upon the skin.

(1) Standing to the outer side of the right thigh, the surgeon passes his arm beneath the limb, and, bringing his hand as far as possible over the front of the thigh, he begins the incision in the skin with the heel of the knife, at a spot as low down upon the external surface as can be reached. The assistant at the same time has the limb rotated forcibly inwards. The knife is now made to pass across the anterior, internal, and posterior surfaces of the limb (in order), being drawn from the heel to the point. The assistant rotates the thigh in an opposite direction

as the knife passes round, the limb being fully rotated outwards when the incision is completed. If the skin-cut be not made at one sweep, the ends of the wound should be joined by an incision from above downwards.

The surgeon, standing on the inner side of the left thigh, follows a precisely opposite course, the incision being commenced upon the inner aspect of the limb.

(2) The assistant now retracts the skin while the surgeon frees it all round. It must be retracted evenly, so as to preserve the original obliquity of the incision. It is seldom possible to turn back a cuff of skin, as some advise. In a normal adult limb such a course is mechanically impracticable.

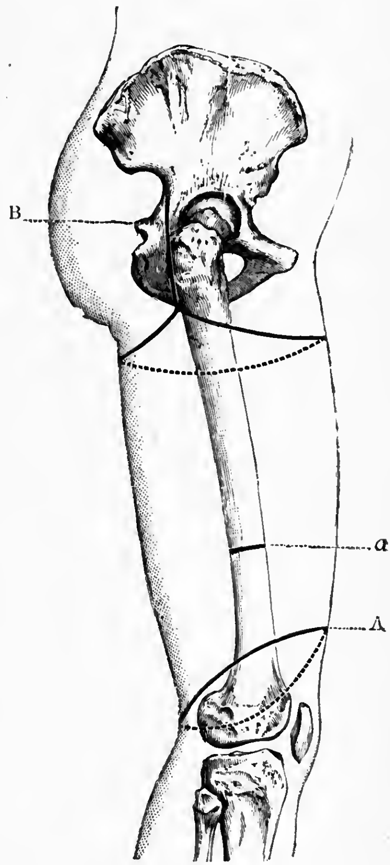

FIG. 422.—A, Circular amputation of thigh: *a*, Saw-line of same; B, Disarticulation at the hip by external racket incision.

(3) When the skin has been separated from the deeper parts and retracted as far as required, the superficial muscles on the inner and posterior aspects of the thigh (the hamstrings, sartorius, and gracilis) are divided by a vigorous sweep of the knife. When they have retracted, the deeper muscles are severed down to the bone at the highest possible level by another sweeping cut.

In dividing the muscles the obliquity of the original incision is still maintained—i.e. the knife crosses the limb parallel to the original skin-cut, and as close as possible to the now retracted margin of the integument.

(4) The bone is cleared, retractors are applied, and the femur is sawn through. " In sawing the femur the position of the thick ridge (linea aspera) at its posterior aspect is to be remembered, and the saw, at first horizontal, must be brought nearly vertical so soon as a groove is cut, in order that the linea aspera may be divided early, and not left to break and form a projecting spike " (*C. Heath*).

It is well to saw off the superior and inferior margins of the end of the bone obliquely, so as to round it. This may be conveniently performed with a small Butcher's saw.

The cicatrix will be transverse or oblique. In the latter case it will incline in front backwards and inwards.

Hæmorrhage.—The position of the femoral artery upon the face of the stump will depend upon the level at which the tissues are divided.

If the amputation be through the lower third of the thigh, the anastomotica magna will be divided. If above this level, the profunda will be found to be cut. The descending branch of the external circumflex artery will require a ligature, as it lies cut on the antero-external aspect of the stump. One or more of the perforating arteries and many muscular branches may need to be secured.

2. **Syme's Modification of the Circular Amputation.**—By this method the circular operation is simplified. The skin is much more easily dissected up, and the integuments are less roughly handled in the process of separation.

The *operation* consists practically of the usual circular incision, with two lateral cuts to aid the retraction of the skin.

Two very short antero-posterior flaps of semilunar outline and of equal width and length are dissected up. They are composed simply of the integument and subcutaneous tissues, and consist of little more curved incisions made across the front and the back of the thigh, each being equal to one-half of the circumference of the limb.

The skin beyond the little flaps is in its turn separated—just as in the usual circular method—and is reflected until a point is reached some two inches above the bases of the small antero-posterior flaps.

The anterior femoral muscles are now divided down to the

bone by a transverse sweep of the knife at the level of the retracted skin. The posterior muscles are severed in like manner, but at the level at which they were first uncovered in forming the posterior flap.

"The muscles," as Syme puts it, "should be divided right down to the bone, on a level as high as they are exposed in front, as low as they are exposed behind."

The muscular tissue after division is further retracted, so as to clear the bone well. The femur is ultimately sawn about two inches above the level of the spot at which the anterior muscles were divided.

3. **Amputations by Long Anterior and Short Posterior Flaps.**—It is assumed that the femur is to be divided about its centre. The two flaps are **U**-shaped. The anterior flap is equal in length to one diameter and a half of the limb at the saw-line. The posterior flap has the length of one-half the diameter of the extremity at the same level. The anterior flap is the wider, its base slightly exceeding half the circumference of the limb (Fig. 423, A).

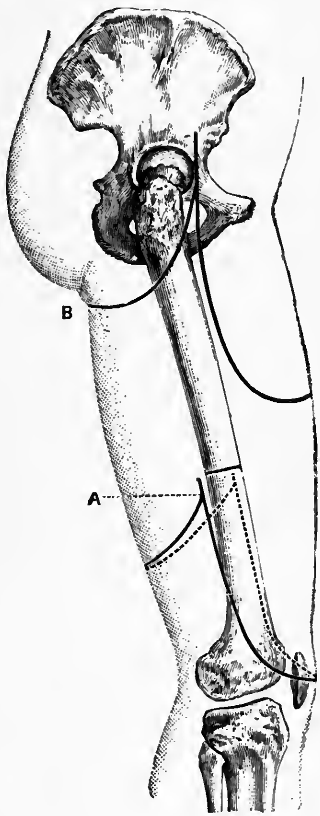

FIG. 423.—A, Amputation of the thigh by long anterior and short posterior flaps; B, Disarticulation at the hip by antero-posterior flaps.

Operation.—(1) The limb is rotated outwards on the right side, and inwards on the left. The anterior flap is marked out first. In the right thigh the surgeon commences with the inner limb of the flap, cutting downwards. He then carries the knife across the front of the extremity, and finishes with the outer limb of the flap, the leg being now rotated inwards. In dealing with the left the conditions are reversed, and the cut is first made upon the external aspect. The incision includes the integuments only

In marking out the posterior flap the surgeon's hand is beneath the thigh, and the knife, being entered at the farther limb of the anterior flap, is drawn across the posterior surface and towards the operator. This cut also involves the integuments only.

The leg is again suitably rotated as the knife passes along its course.

(2) The tissues of the anterior flap are now pinched up with the left hand, and the muscles contained therein are divided obliquely from without inwards—i.e. from the skin to the bone. The soft parts are so cut that the flap is thinnest at its extremity and thickest at its base. At the latter site it will include the whole thickness of the muscular mass in front of the femur. The tissues are divided obliquely (the edge of the knife being turned towards the bone at the base of the flap), in distinction to the transverse division of parts which obtains in the circular amputations.

The muscles of the posterior flap may be conveniently cut by transfixion. They may, however, be divided in the same way as are those of the anterior flap. Transfixion is better suited for muscular limbs.

The muscles are divided well down to the bone at the bases of the flaps. The femur is bared by further retraction of the soft parts, and is sawn in the manner already described (page 654).

Spence (" Lectures on Surgery," 2nd ed., vol. ii., page 621, 1876) made the anterior flap equal in length to the diameter of the limb, and the breadth of its base equal to " almost two-thirds of the circumference of the thigh."

The posterior flap was cut from without inwards, and was commenced some two inches below the base of the anterior flap. To this an additional inch of skin was sometimes added. Spence considered this operation as especially applicable to the lower third of the thigh, and the extremity of the large anterior flap was allowed to reach as low as the lower margin of the patella.

Sédillot (" Médecine Opératoire," vol. i., page 455, 1854) made the anterior flap equal to one diameter of the limb at the saw-line, and its base equivalent to " fully one-half of the circumference." There was no posterior flap, the structures at the back of the

limb, from the skin to the bone, being divided by one vigorous transverse cut.

Sédillot's operation, when performed upon a muscular limb, scarcely provides a sufficient covering for the bone.

Hæmorrhage.—The position of the femoral artery, with reference to antero-posterior flaps generally, may be alluded to here.

In an amputation by antero-posterior flaps made above the middle of the thigh, the femoral artery, together with the profunda, will be found in the anterior flap. In a like amputation performed below the middle of the limb the main artery will be divided in the posterior flap. In this position, however, there is risk of splitting the artery if the anterior flap much exceed in width one-half of the circumference of the limb. This is avoided by placing this flap a little towards the external aspect of the limb instead of fashioning it in the median segment. When the amputation is carried out in the middle of the thigh, the anterior flap should be antero-external. This will bring the artery in the posterior flap.

The descending branch of the external circumflex artery will always be found divided in the anterior flap, together with many muscular branches. In the lower third of the limb the anastomotica magna will be divided about the inner part of the hinder flap.

In the angle between the flaps, and in the muscular tissue close to the bone, branches of the perforating arteries will be found cut.

It is needless to say that the muscular arteries in the thigh are large and numerous, and that the great veins require to be occluded by ligature.

Comment.—Owing to the uneven manner in which the muscles of the part retract, and to the extent of that retraction, a conical stump is not uncommon after any amputation of the thigh. The retraction concerns mainly the posterior and internal segments of the limb, and it will be observed that the cicatrix is apt to be drawn backwards and to the inner side. This may be well seen after a simple circular amputation. Conical stumps are more common below than above the middle

of the limb. In amputations made through the lower third of the thigh it should be remembered that the bone comes nearest to the anterior surface. When the limb is divided above the middle of the thigh, the femur is apt to project anteriorly. This is due partly to the contraction of the psoas and iliacus muscles, and partly to the weight and retraction of the posterior muscles.

With regard to the *selection of methods* :—

The objections which have been urged against the circular operation, and the advantages which it may claim, apply very especially to amputations in this region.

The usual circular method cannot be advised, nor is any form of the amputation suited for the middle or the higher part of the limb.

The modified circular operation described (No. 1) and Syme's operation (No. 2) are adapted for the lower third of the limb, especially in cases where a long anterior flap cannot be cut, for children, and for the limbs of enfeebled and wasted subjects. The fact that the wound-surface is comparatively small, that the section of the muscles is reduced to a minimum, and that the main vessels are cleanly divided, are distinctly in favour of this method.

The amputation by a long anterior and a short posterior flap (No. 3) is perhaps the best adapted for the thigh and all parts of it. In the lower third of the limb it is certainly an excellent operation.

After-treatment of Amputations of the Thigh.—The stump should be exposed to the air—covered, of course, by suitable dressings. The thigh should be raised and supported upon a firm pillow or cushion, to which it should be lightly secured. The limb should be placed in the abducted position. The extremity of the stump should project beyond the end of the pillow. It will be thereby exempted from pressure, and drainage will not be interfered with. A supporting splint is not required in these amputations, although it may sometimes be employed with advantage after the circular operation and in amputations through the lower part of the limb.

A few sutures should be omitted at the most dependent angle of the wound, to allow for drainage—or, better still, a short tube may be inserted at that situation. The oozing during the first twenty-four hours is considerable.

In no case should a large drainage-tube be drawn right through the depths of the wound from one extremity of the incision to the other.

As the flaps are large and heavy, the sutures should not be removed too soon. After their removal, the flaps may need to be supported for a while by strapping.

CHAPTER XII

DISARTICULATION AT THE HIP-JOINT

THIS amputation, the most serious the surgeon can be called upon to perform, was for many years after its introduction attended by so terrible a mortality as to be considered an entirely unjustifiable operation.

The first amputation at the hip appears to have been performed by Mr. Henry Thompson, surgeon to the London Hospital, some time before 1777. Previous to this—viz. in 1743—Ravaton had elaborated an operation, which, however, his surgical colleagues would not allow him to perform. His method consisted in a vertical external incision, through which the bone was to be enucleated subperiosteally, and disarticulation effected; the operation was to be completed by a circular section of the soft parts. This procedure is practically identical with the modern operations of Esmarch, Lister, Furneaux Jordan, and others (page 664).

Kerr, of Northampton, amputated at the hip in 1778, using an oval incision, the *queue* of which terminated externally. Through the outer part of the wound disarticulation was effected, the soft parts upon the inner side of the limb being divided subsequently.

The first amputation at the hip in military practice is accredited to Baron Larrey in 1793. In all these early cases the patients died.

Earle, writing in 1808 ("Pott's Chirurgical Works," vol. iii., page 217), speaks of the operation as "horrid," "dreadful," and "unjustifiable," and adds: "I have seen it done, and am now very sure I shall never do it, unless it be on a dead body."

The mortality after this operation has been already considered (page 487).

In designing the operation in any particular case, allowance must be made for the great retractility of the skin in this part of the limb, and for the contraction of the divided muscles.

Should an artificial limb be worn after the operation, it must, of course, take its support from the pelvis, and princi-

pally from the ischium. It is well, therefore, that there should be a good internal flap, and that the cicatrix should be removed from the tuber ischii. At the same time, the operation wound must be so arranged as to allow for efficient drainage.

In this amputation no little value must attach to methods of operation which can be effected with rapidity.

Anatomical Points.—The following landmarks may be noted :—
The pubic spine is on a level with the great trochanter. The summit of the great trochanter is on a level with the centre of the hip-joint. The gluteal fold is some way above the lower margin of the gluteus maximus muscle, with which it does not correspond.

The subcutaneous tissue about the hip is lax.

The following are the muscles attached to the upper third of the femur : The three glutei, the two obturator muscles, the two gemelli, the pyriformis, the psoas and iliacus, the pectineus, the adductor brevis and adductor magnus, the quadratus femoris, and portions of the vasti and crureus.

The remaining muscles divided in the operation are the tensor vaginæ femoris, the rectus, the sartorius, the gracilis, the adductor longus, and the three hamstring muscles.

Several bursæ exist about the hip, the largest and most noteworthy being one between the great trochanter and the gluteus maximus, and another between that muscle and the vastus externus. The hip capsule is thickest in front, at the site of the ilio-femoral ligament. It may here measure one-fourth of an inch in section.

The femoral artery is separated from the capsule of the hip by the psoas muscle, upon which it lies. The profunda arises one inch and a half below Poupart's ligament ; the internal and external circumflex arteries two inches below that ligament. At the apex of Scarpa's triangle—some three to four inches below Poupart's line—the great vessels have the following relation to one another from before backwards : femoral artery, femoral vein, profunda vein, profunda artery.

The profunda is about the size of the brachial artery, the external circumflex of the ulnar, the internal circumflex of the lingual.

The last-named vessel runs horizontally backwards through the substance of the limb, about the level of the lesser trochanter. It gives a branch to the hip-joint.

The external circumflex artery passes more or less directly outwards.

The first perforating artery runs backwards at the lower border of the pectineus muscle.

The sciatic artery gives off numerous branches, most of which are cut in the amputation. The comes nervi ischiadici—the terminal part of the vessel—is the size of the supra-orbital artery.

No large branch of the gluteal artery is divided, although the inferior branch of the deep division will be cut near its extremity.

The obturator artery itself is not concerned in the operation, and the branches of it which are divided are very small—e.g. the branches to the adductors and to the hip.

In the hollow on the inner side of the great trochanter is an anastomotic network which is derived from the gluteal, sciatic, internal circumflex, and first perforating arteries.

Mode of Controlling Hæmorrhage during the Operation.—Various methods have been adopted for preventing excessive hæmorrhage during this disarticulation.

1. The femoral artery may be ligatured either before the flaps are cut or during the fashioning of the flaps when the incision crosses the line of the artery, as in the method known as the "anterior racket" (page 669).

The procedure involves a little time, and, when a special incision has to be made, somewhat complicates the operation. The method, however, has many advantages. It has been urged by some surgeons that the artery is apt to be secured unnecessarily high up, and that the vitality of the main flap may be in consequence impaired, but this objection has not been confirmed by practice.

The femoral may be compressed in the flap by the fingers of an assistant, who grasps the base of the flap just before the vessels are divided. This method is illustrated in the amputation by transfixion (page 670).

Some surgeons advise digital compression of the femoral or external iliac. This can, however, hardly be carried out except in a child. The fingers are very apt to slip during the manipulation of the limb.

In all these methods it is needless to say that the securing of the femoral does not affect hæmorrhage from the branches of the internal iliac artery,

2. To prevent hæmorrhage from branches of both external and internal iliac arteries during the operation, Sir William Macewen strongly recommends manual pressure on the aorta.

The assistant who does this should stand on a stool placed on the left side of the patient ; by crossing his right leg over the left one he throws the weight of his body on to his doubled-up right hand, which is made to compress the aorta at the level of the umbilicus. The pressure, which can be maintained during a long operation without undue fatigue, need only be sufficient to stop the femoral pulsation, tested by the assistant's left hand.

We have no personal experience of this method, and it is open to the objections that in a stoutly built subject pressure on the aorta would be difficult and that the intervening intestines might suffer damage. Still the method has the approval of a very high authority in Sir William Macewen.

3. Clamping the common iliac artery is a most efficient measure, and one we can strongly recommend. The artery is reached by the extraperitoneal route and secured between the blades of a suitable metal clamp : a straight intestinal one answers well. Just sufficient pressure is applied entirely to stop the pulse in the thigh. For further details see page 428.

One or other of the above methods will probably be chosen by the surgeon. The elast c tourniquet, usually applied with the help of metal skewers thrust through the limb, has been used by Wyeth, Jordan, Lloyd, and others, but this seems clumsy as compared with the methods given above.

Precautions against shock.—Every provision must be taken against shock. The limbs should be well wrapped up, the body enveloped in a blanket, and the head kept low. A stimulant may be given before the operation, and means should be at hand to administer brandy by enema or subcutaneous injection if required. Three or four preliminary injections of strychnia at intervals of an hour ($\frac{1}{60}$ to $\frac{1}{30}$ grain at each injection) may well be given, and all arrangements should be made for transfusion of normal saline solution into the veins or subcutaneous tissue. The transfusion, if advised, should be begun at the commencement of the operation, so that three or more pints of fluid may be slowly transfused before the patient leaves the table.

Methods of Operating.—The different methods advised by different surgeons for amputating at the hip-joint are exceedingly numerous. Farabeuf gives figures of no less than twenty-five different procedures, and, if each operation were to

be named after the surgeon designing it, it would be necessary to describe some forty methods of disarticulation at the hip.

Many of these operations have long since been abandoned, and many differ from one another in but very trifling particulars.

In the account which follows it is only possible to deal with certain typical methods, without attempting to pursue the individual modifications of particular surgeons.

The following modes of performing this amputation will be described :—

1. Disarticulation through an external racket incision.
2. Disarticulation through an anterior racket incision.
3. Disarticulation by antero-posterior flaps (transfixion).
4. Guthrie's operation.
5. Other methods of disarticulation.

1. **Disarticulation through an External Racket Incision.** *Instruments.*—A stout amputating-knife with a blade some six inches in length, and with not too fine a point ; a large stout scalpel or resection knife ; an amputating-saw ; lion forceps if the bone is to be divided (*see* Esmarch's operation, page 668) ; artery forceps ; pressure forceps ; dissecting forceps ; scissors, long needles, etc. If the operation is to be subperiosteal, a periosteal elevator or rugine is required.

Position.—The body is drawn down until the pelvis rests upon the extreme lower edge of the table. The sound limb is secured out of the way. The patient is turned sufficiently over on the sound side to expose the postero-external aspect of the limb to be removed. Some care has to be taken to prevent the patient from slipping entirely off the table. The surgeon stands on the outer side of the thigh—in the case of both the right and the left extremities—and faces the patient.

In the case of the left limb it may be sometimes more convenient to stand on the inner side of the thigh between the limbs.

The assistant standing above the surgeon attends to the tourniquet and supports the flap during the ligaturing of the vessels after the tourniquet has been removed. Another assistant manipulates the limb, while a third, standing opposite to the

surgeon, attends to the sponging and assists in the disarticulation, in the fashioning of the flaps, and in securing the vessels.

The Operation.—(1) The limb being adducted and a little flexed and rotated in, the knife is entered about two inches above the upper edge of the great trochanter, and is carried vertically down the limb along the posterior border of the trochanter for about seven inches. The knife is now drawn across the limb in front and behind in the form of two crescentic incisions, which meet on the inner side of the thigh some little way below the termination of the vertical incision and some inches below the genito-crural angle. The whole of this extensive cut should at first involve only the skin and the subcutaneous tissues. At the outer aspect of the limb the incision forms a large inverted **Y** (Fig. 422, B). While the oblique incision is being made, the assistant may rotate the thigh a little so as to make the tissues meet the surgeon's knife.

(2) The surgeon now turns to the oblique incision encircling the thigh, and separates the skin and subcutaneous tissues all round until these parts have been raised to the extent of about two inches.

This is effected precisely as in the ordinary circular operation, the limb being rotated as required.

(3) The thigh being now again adducted, rotated in and a little flexed, the knife is carried well down to the femur along the whole length of the vertical incision.

The muscles attached to the great trochanter must next be divided close to the bone. The anterior, superior, and posterior borders of the trochanter should be cleared in order. The first muscle to be divided is the gluteus medius, attached to the outer surface of the process. The obturator externus tendon is apt to escape division as it dips into the digital fossa. In clearing the process the limb must be kept extremely adducted and well rotated in. A short stout knife—such as is used in Syme's amputation or in resection operations—is very convenient at this stage. The knife must be carried vigorously down to the bone.

The upper part of the shaft of the femur is now cleared as far as the vertical incision extends. The soft parts must be liberally cut, care being taken that the femoral and profunda arteries are not encroached upon.

In this step the insertions of the gluteus maximus, quadratus femoris, psoas, iliacus, pectineus and upper adductor fibres are divided, together with the superior portions of the triceps femoris. The surgeon is aided by an assistant, who draws the divided soft parts away so as to expose the bone well.

(4) The bone has now to be disarticulated. The capsule may be divided transversely at its upper and posterior parts while the limb is in the position of extreme adduction. The anterior part of the capsule can be severed while the thigh is a little flexed.

The limb is now rotated outwards to its utmost, the joint opened, and the round ligament cut.

Everything about the upper end of the femur should now be free and ready for the final sweep of the knife.

Up to this point no vessels of any magnitude have been divided, the chief arteries concerned being the internal circumflex, some branches of the external circumflex and of the sciatic, and a few muscular vessels.

(5) Nothing now remains but to cut the muscles upon the inner side of the limb by a vigorous circular sweep of the knife at the level of the already retracted skin. A few touches of the blade, and the limb is removed.

The great vessels are at once secured.

If the operation is to be "subperiosteal," the femur is stripped of periosteum by means of the elevator, the muscles being, so far as is possible, detached with it. This separation cannot be followed farther than the base of the femoral neck, and involves a considerable expenditure of time. Along the linea aspera the detachment of the periosteum is exceedingly difficult. The value of this modification of the more ready method is discussed later.

Hæmorrhage.—In securing the bleeding points the assistant holds up the anterior part of the flap so as to expose well the whole wound surface. Care must be taken that any tourniquet applied does not slip when the limb is removed.

The great vessels are found severed on the anterior face of the wound, close to the divided rectus, sartorius, and adductor longus muscles.

The vessels are placed one behind the other in the following

order from before backwards: The femoral artery, the femoral vein, the profunda vein, the profunda artery.

The first vessel to be sought for after the main trunks are ligatured is the internal circumflex. It will be found divided in the tissues about the inner and posterior side of the acetabulum. The branches of this artery often give much trouble. The descending branch of the external circumflex is found cut close to the inner edge of the vastus externus. The transverse branch of that artery will also probably require a ligature.

In the posterior segment of the wound the comes nervi ischiadici is early recognised, and will require ligature.

Bleeding will occur from other branches of the sciatic artery, and from many muscular branches distributed about the surface of the wound.

Varieties of the Operation.—The first operation designed for the removal of the lower limb at the hip-joint was in all essential points identical with that just described. The surgeon was Ravaton, the date 1743.

The amputation also performed by Kerr, of Northampton, in 1778, was practically upon the same lines.

Kerr's external incision was in the form of an inverted **V**, and not of an inverted **Y**, as in the procedure just detailed.

Foullioy employed the external racket incision in 1841, having first ligatured the common femoral at the fold of the groin.

Malgaigne's operation (*en raquette*) was like the present procedure, except that the vertical incision was shorter and the circular incision therefore more oblique.

The following methods require more extended notice:—

(*a*) *Lister's*.—The above description of disarticulation at the hip is founded upon the sketch of an operation given by Lord Lister ("Holmes's System of Surgery," vol. iii., page 721). Lister made the external incision eight inches in length (for an adult), and divided the soft parts around the inner side of the limb before the femur was cleared. The disarticulation of the bone was the last step of the operation. He furnished no directions for the precise performance of the operation, and founded its principles upon the procedure of Furneaux Jordan.

(*b*) *Furneaux Jordan's*.—Mr. Jordan ("Surgical Enquiries," 2nd edition, page 303) gives the following description of his operation:—
"A straight incision was made, and the trochanters and upper part

of the shaft were freed from their muscular attachments, after which the capsule was opened. Next the shaft was cleared downwards from all its attachments for a considerable distance, and then a few free sawing movements with a long-bladed knife through the thigh, from which the bone had been removed, ended the operation. The integuments were simply drawn upwards, and the soft parts were cut straight through. No bone being left, the muscles quickly retracted, and were easily covered by the skin. Very little blood was lost. . . . The principle of the operation may be thus described : First enucleate the bone, then cut through the limb at any desired spot—the middle of the thigh, or below, or even near the knee."

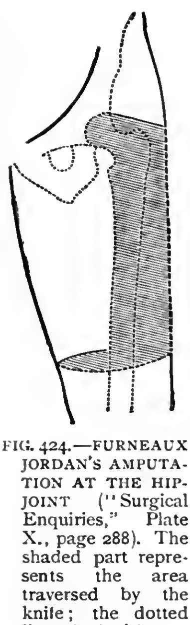

FIG. 424.—FURNEAUX JORDAN'S AMPUTATION AT THE HIP-JOINT ("Surgical Enquiries," Plate X., page 288). The shaded part represents the area traversed by the knife; the dotted lines the incision.

It is evident from this description, and from the diagram of the operation given by Mr. Jordan (*see* Fig. 424), that his disarticulation differs very considerably from the procedures associated with his name by more than one writer.

(*c*) *Esmarch's*.—Mr. Barker ("Manual of Surgical Operations," 1887) gives the following account of Esmarch's operation, in favour of which he speaks :—

"By a single, strong, muscular sweep of the knife five inches below the tip of the trochanter, all the soft parts of the thigh are divided completely to the bone, and the latter is at once sawn across.

"The vessels are then ligatured.

"The bone is now seized in a lion forceps and steadied, while a second incision is made, commencing two inches above the tip of the trochanter, and carried down along the latter, to terminate in the first circular cut. The two borders of this incision being held apart by an assistant, the bone is cleared of the soft parts by the use of an elevator inserted under the periosteum, and by the knife where the muscle-insertions are too firm for the latter. When the capsule is reached it is divided, and the head is dislocated in the usual way."

2. **Disarticulation through an Anterior Racket Incision.**—This method is also known as the anterior oval method.

It is founded upon the operations performed by Larrey in 1793, by Sir Astley Cooper in 1824, by Roser in 1856, and later

by Verneuil. In the account of the operation the admirable description of Farabeuf is followed.

The same *instruments* are required as are used in the previous operation. In addition to those mentioned, an aneurysm-needle and a small scalpel will be needed. Retractors are occasionally employed.

The *position* of the surgeon and of his assistants is the same. The patient is so placed that the pelvis rests upon the extreme end of the table and the trunk evenly upon the back.

The Operation.—(1) No tourniquet is applied. The incision is commenced at the centre of Poupart's ligament, and is carried downward along the course of the femoral vessels for about three inches. It is then made to curve inwards so as to cross the adductors about four inches below the genito-crural fold. The knife then sweeps over the posterior aspect of the thigh, crosses the outer side of the limb a little way below the base of the great trochanter, and is carried obliquely across the anterior aspect of the thigh to meet the vertical incision about two inches below its point of commencement (Fig. 425).

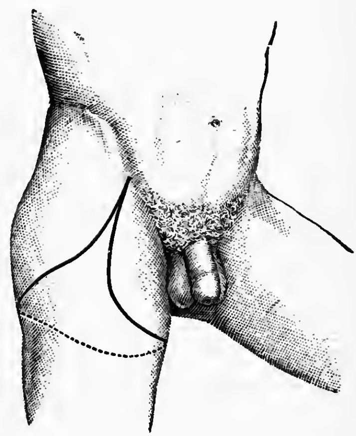

FIG. 425.—DISARTICULATION AT THE HIP-JOINT BY AN ANTERIOR RACKET INCISION.

This incision concerns at first only the skin and the subcutaneous tissue. It cannot be made with one sweep of the knife, and the limb must be so held and so rotated as to make the tissues meet the knife.

(2) The femoral sheath is now exposed at the upper part of the incision, and the vessels are laid bare by dissection. The common femoral artery is ligatured in two places close together, and is divided between the ligatures. The femoral vein is secured in the same manner, and then cut across at the same level as the artery.

(3) The skin is freed all round the whole length of the incision,

and is allowed to retract a little. The integuments, however, are not especially dissected up.

(4) The stout scalpel is now taken, and is carried through the muscles in the outer flap. In this way are divided the sartorius, the rectus, and the tensor vaginæ femoris. The retraction of these muscles will expose the external circumflex artery, which is secured between two ligatures and divided.

Carry the knife backwards, rotate the limb in, and divide the insertion of the gluteus maximus. Rotate the limb out and divide the psoas muscle. At this point the internal circumflex artery is exposed, secured, and divided. Retractors are of use at this stage of the operation.

(5) The muscles in the inner flap are now cut at the level of the retracted skin. These include the pectineus, the gracilis, and the superficial adductors. Any divided vessels are secured.

(6) Adduct the thigh, and rotate it inwards so as to expose the great trochanter. Divide the insertions of the muscles attached to this process, notably the gluteus minimus and medius.

(7) Abduct the limb and rotate it out. Incise the capsule transversely. Disarticulate. Divide the round ligament and also the obturator externus tendon, if it has up to the present escaped division.

(8) The limb being still more rotated outwards, the head of the femur is dragged forward, and the longer knife being passed behind the bone, all the soft parts at the posterior aspect of the limb are divided with one sweep of the blade at the level of the retracted skin. These tissues will include the hamstrings, the great sciatic nerve, and the undivided parts of the adductors, principally represented by the adductor magnus.

When the wound is approximated, there should be no strain upon the sutures, which are deeply applied.

Hæmorrhage.—It is a feature of this operation that the vessels are ligatured as they are exposed, the surgeon dealing with the hæmorrhage according to the method adopted during the removal of a large tumour. In my experience of this operation the loss of blood has been quite insignificant.

3 **Disarticulation by Antero-Posterior Flaps (Transfixion).**—This operation was at one time very extensively practised in England.

The method is frequently known as Liston's operation. It has been very well described by Fergusson, and has been associated with the names of many French surgeons.

The great feature of the operation consists in the rapidity with which it can be performed. Fergusson states that the procedure can be completed (so far as the use of the knife is concerned) in from twelve to twenty seconds.

This was a matter of no little moment before the days of ether and chloroform.

The anterior flap is long and **U**-shaped. The posterior flap is shorter, and is more squarely cut.

No tourniquet of any kind is employed. Even the elastic band would be in the way, and would probably slip during the somewhat vigorous movements to which the limb is subjected. The main vessels are secured in the flap itself by the fingers of an assistant, who compresses them during the actual cutting of the flap.

Instruments.—A pointed amputating-knife, having a length equal to one and a half times the diameter of the limb at the level of the hip. Artery forceps. Ten or fifteen pressure forceps. Scissors, needles, etc.

Position.—The patient is supine, and the buttocks rest upon the extreme edge of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the limb in the case of both the right and the left extremity. One assistant stands above the operator. His duty is to attend to the anterior flap, to compress the main vessels as the flap is being cut, and to hold it out of the way during the disarticulation. A second assistant stands opposite to the surgeon to assist generally, and to seize any bleeding points as soon as the limb is separated. A third helper may stand near the patient's shoulders (on the opposite side), to steady the pelvis and prevent the body from slipping off the table. The fourth assistant manipulates the limb. This office is of exceeding importance. The rapidity with which the disarticulation can be effected depends largely upon the smartness of this assistant.

The limb is made to assume a different position at each step of the operation.

(1) The limb is a little flexed and a little abducted. The knife is entered midway between the anterior superior iliac spine and the top of the great trochanter, is thrust through the limb parallel with Poupart's ligament, and is brought out at the inner side of the thigh behind the adductor longus, about one inch in front and one inch below the tuber ischii, and some three inches from the anus.

The knife should graze the head of the femur in its passage, and just open the hip capsule. It is passed, therefore, as deeply as possible.

If reasonable care be not taken, the knife may slice the femoral vessels, or may be arrested by the femur, or may enter the thyroid foramen, or may have its point driven into the testicle or the thigh of the opposite side.

The surgeon now cuts, by a sawing movement of the knife, a U-shaped anterior flap some eight inches in length.

This flap will end about the junction of the upper with the middle thirds of the thigh (Fig. 423, B). It should include as much of the soft parts as possible.

It will be noticed that the knife is placed obliquely at the commencement of the cutting of the flap, and that it becomes transverse at the termination. More tissue has to be divided on the outer than on the inner side of the limb. If the flap be carelessly cut, it is apt to be too pointed at its extremity.

As the knife is carried downwards, the first assistant slips his fingers under the cut surface of the flap and compresses the main vessels against his thumbs, which are placed upon the skin. It thus happens that before the femoral is divided at the end of the flap the upper part of the trunk is well secured.

As soon as the flap is made this assistant draws it upwards out of the surgeon's way, while he still grasps the great vessels.

(2) The limb is straightened and is fully extended, i.e. the knee is depressed. The surgeon cuts open the capsule.

The thigh is now rotated outwards. The head slips out of the acetabulum, and the round ligament is divided.

The thigh, still extended, is now rapidly adducted and rotated inwards, and the muscles about the great trochanter are cut.

The disarticulation is complete, and nothing remains but to cut the posterior flap.

(3) The whole thigh is now lifted directly up in such a way that the free end of the femur is dragged away from the posterior tissues and is forced forwards.

The surgeon passes his knife behind the femoral head and the great trochanter, and, cutting downwards, forms the posterior flap.

This flap is shorter than the anterior, and the skin is divided about the level of the gluteal fold (Fig. 423, B).

The clearing of the great trochanter is perhaps the most difficult part of the operation. If it is not well done, a pocket is left in the flap at the site of that process.

Hæmorrhage.—The sciatic artery and branches of the gluteal in

the posterior flap should first be secured ; then the internal circumflex, close to the inner side of the acetabulum. The superficial femoral is divided near to the free extremity of the anterior flap. The profunda is usually found severed about the middle of the cut surface of the flap. In the outer part of the same flap the external circumflex will be found, and will require a ligature. The femoral and profunda veins should be ligatured.

Varieties of the Operation.—Some surgeons have preferred to make an anterior flap only, cutting the soft parts at the back of the limb with a single sweep of the knife at right angles to the axis of the femur.

The anterior and posterior flaps have been made of the same length, i.e. about five inches.

Fergusson made the anterior flap four inches in length and the posterior "somewhat longer."

Béclard cut the posterior flap first.

4. **Guthrie's Operation.**—This is the best type of operation by flaps cut from without inwards. The flaps are short and oblique, and are placed antero-posteriorly.

The Operation.—This is described in Guthrie's "Commentaries" (5th ed., 1853, p. 76). "The anterior flap should be about five inches long, the posterior two-thirds the length of the other. The two incisions start from just above the great trochanter (three or four inches below the anterior superior spine), and end on the inner side just below the tuber ischii. The rounded convex flaps are shaped out of the skin and fascia.

"The integuments, including the fascia, being retracted, the three gluteal muscles are to be cut through to the bone. The knife being then placed close to the retracted integuments, cuts steadily through everything on the anterior part and inside of the thigh. The femoral or other large artery may then be drawn out and tied.

"The capsular ligament being well opened, and the ligamentum teres divided, the knife should be passed behind the head of the bone thus dislocated, and made to cut its way out, care being taken not to have too large a quantity of muscle on the under part, or the integuments will not cover the wound."

5. **Other Methods of Disarticulation.**—Of the many other procedures not here described, it is necessary only to allude to the amputations by *lateral flaps*.

These operations are still advised by some surgeons in cases of limited injury of the front of the thigh, as in gunshot wound, and

in cases where a growth projects towards the anterior part of the limb. Very unwieldy stumps are left, and these methods have little or nothing to recommend them.

Fig. 426 shows the incisions in *Lisfranc's method.* The flaps are cut by transfixion, the outer one being made first. After disarticulation has been effected the inner flap is cut. The vessels are ligatured as exposed. Each flap is about four inches in length, and both are very bulky.

The names of Larrey, Blandin, and Dupuytren are especially associated with these lateral flap operations.

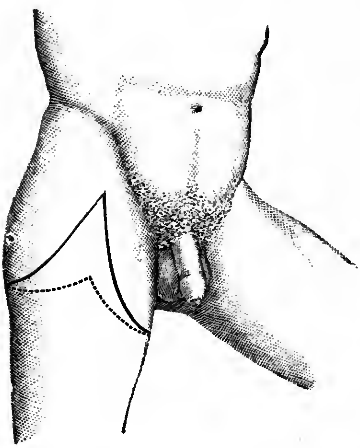

FIG. 426.—LISFRANC'S DISARTICULATION AT THE HIP BY INTERNAL AND EXTERNAL FLAPS.

An excellent atlas of the various methods of amputating at the hip-joint is given by Farabeuf in his "Précis de Manuel Opératoire," 1885, page 634.

Comment.—Of these various operations, those by the *racket method* may be considered to be the best.

Of the two methods involved, that which employs the anterior incision appears to me to be the more useful.

With no other form of disarticulating at the hip-joint have I experienced such good results as with this method.

1. The *external racket method* has the following points to recommend it :—

(*a*) The elastic tourniquet can be applied.

(*b*) The femur is approached through the least vascular part of the limb, and disarticulation may be effected before the main mass of the muscles of the thigh has been cut.

(*c*) The vessels of the part are divided transversely, and the main artery is severed late in the operation.

(*d*) Owing to the low position of the incision posteriorly, the branches of the gluteal and sciatic artery are but little interfered with, and the hæmorrhage from these vessels is comparatively trifling.

(*e*) The muscles are divided transversely, and the wound surface therefore is small. The main muscular masses are divided low down, so that in a sense the limb is removed at a point farther from the trunk than obtains in some of the other amputations, and shock is thereby diminished.

(*f*) An excellent stump is provided—i.e. the ischium (the main point from which the future artificial limb will take its support) is well covered; the cicatrix is brought to the outer side of the limb, and is as far removed from the anus as possible; excellent drainage is provided for.

(*g*) The position of the vertical incision will permit of the hip being explored before operation, or of an excision being carried out should it be revealed that amputation is not necessary.

In *Furneaux Jordan's* operation the muscles may be divided still lower down, i.e. about the middle of the thigh or near the knee.

Although the circular incision is made low down in the limb, and though a more slender segment of it is divided, it must be remembered that the deep vertical incision required to expose and resect the femur is proportionately increased in length. Bleeding from this vertical wound may be considerable, since several of the perforating arteries are cut.

Shock is no doubt much diminished by dividing the soft parts low down. With regard to the long, boneless stump left, Mr. Jordan writes:—"If the thigh were to remain a soft, pendulous mass, it would be a small price to pay for greater safety; but it is a remarkable circumstance that, as a rule, the muscles do not rest until the longest stump has become a short one."

Esmarch's method has the advantage of being rapid, and is, moreover, easily performed. The vessels are divided and secured at an early stage of the operation. This procedure is well adapted for the application of the subperiosteal method.

2. The disarticulation through an *anterior racket incision* has many of the disadvantages of the previous operation, and has other special claims of its own.

(*a*) All forms of elastic tourniquet can be dispensed with.

(*b*) The muscles are divided transversely, and the wound surface is comparatively small.

(*c*) The division of the great mass of the muscles is made low down.

(*d*) The vessels in the posterior part of the limb are but little interfered with.

(*e*) The main vessels are ligatured early, and the other arteries are secured as they are cut.

(*f*) The hip-joint is directly exposed, and disarticulation is most easily effected.

Compared with the external racket method, the present procedure has these possible disadvantages :—

The femur is exposed through a muscular and vascular part of the thigh, and the vertical incision made is not quite so well adapted for a mere exploratory cut, nor for an excision wound should amputation be at the last moment abandoned.

The procedure is less rapidly effected, although the actual disarticulation is easier. This depends upon the fact that the smaller divided vessels are more easily dealt with after the limb has been removed than during the cutting of the flaps. The double-ligaturing of the main vessels also involves time.

The stump is good, the ischium is well covered, the edges of the wound come easily together, but the flaps are not quite so well adapted to favour ready drainage.

3. The operation by *antero-posterior flaps cut by transfixion* has the one advantage of great rapidity of execution. Before the days of chloroform this was an advantage of the primest value.

In many instances at the present time, especially in cases of amputation for injury, rapidity of execution is of very considerable importance. It must be considered to what extent this single great advantage can overbalance the following grave disadvantages :—

(*a*) A tourniquet can only with difficulty be applied.

(*b*) The flaps cannot be very accurately cut.

(*c*) The muscles are divided obliquely, and the wound surface is very considerable.

(*d*) The soft parts are divided high up, consequently there should be greater shock.

(*e*) The branches of the gluteal and sciatic arteries are so freely cut that copious hæmorrhage from the posterior flap is common.

(*f*) The stump does not provide a very excellent covering

for the ischium. The cicatrix is exposed to pressure; the wound is carried very near to the anus, and efficient drainage is not provided unless drainage-tubes are employed.

The operation has no advantage that adequately compensates for these drawbacks.

4. *Guthrie's operation* is strongly recommended by several writers. Ashhurst ("Encyclopædia of Surgery") considers it to be, without reserve, the best mode of amputating at the hip-joint.

The operation occupies a position but little inferior to that held by the external and anterior racket methods.

The same advantages can be claimed for it as are claimed for the latter operation. The muscles are, however, not divided so transversely, and disarticulation is not quite so readily effected. The operation is, on the other hand, more rapidly performed, and the femur is exposed through a less fleshy and vascular part of the limb.

The operation is inferior to the external racket method for reasons that need not be recapitulated.

An excellent stump results: the ischium is well covered; the wound is brought more to the outer side of the extremity, and is well adapted for efficient drainage; the cicatrix is small and protected from pressure.

After-treatment of Amputations at the Hip-joint.—After the operation all necessary means should be taken to prevent severe shock. The head should lie low, the body be well covered with blankets and kept warm by hot bottles, and, if necessary, enemata of brandy may be administered. Transfusion of saline solution may need to be carried out during or after the operation, and strychnia injected. (*See* page 663.)

By means of a suitable cradle the stump can be left uncovered and the dressings be exposed to the air. The stump should be supported upon a firm pillow or cushion, care being taken that no pressure is exercised upon the wound.

If every care be taken, the great wounds left by these operations will heal up throughout by first intention. There is always a considerable discharge of sero-sanguinolent matter from the large wound surface. In the racket operations, and

in Guthrie's disarticulation, drainage may be secured by omitting a suture or so at the most dependent point of the wound. In the transfixion operation by antero-posterior flaps a drainage-tube will most probably be required.

The first dressings should be voluminous, and firmly secured by an elastic bandage forming a figure of " 8 " round the pelvis. On its inner and front aspect the dressing should be covered with pink macintosh. It is important to defer the changing of these dressings for three or four days if possible, as it may ncrease the shock. There may be retention of urine requiring use of a soft catheter.

The weight of the flaps renders it important that the sutures should not be removed too soon, and after their removal it will, as a rule, be found necessary to support the flaps by strapping.

Care must be taken that the dressings are not soiled by urine or fæces, and that bed-sores do not form over the sacrum or the trochanter of the opposite side. As the action of the bowels may disarrange or soil the dressings, it is best to keep them from acting for four or five days by a small opiate.

PART VII.—OPERATIONS ON BONES AND JOINTS

CHAPTER I

OSTEOTOMY

By osteotomy is understood the division of a bone in its continuity for the relief of deformities of various kinds.

Linear osteotomy implies the division of the bone in its continuity in a single line, usually transverse and made by the subcutaneous method. *Cuneiform osteotomy* is the term applied to the cutting-out of a wedge-shaped piece for the relief of such deformity as that represented by the curved tibia met with in rickets. *Osteotomy with resection* of part of the shaft of a long bone is done occasionally to bring two unequal limbs approximately to the same length (*see* page 687).

In all these forms the operation may be performed by means of a saw, or a chisel, or an osteotome.

Instruments employed.—The following are the instruments required in these operations: (1) An ordinary scalpel; (2) chisels and osteotomes of various sizes; (3) mallet; (4) saws for subcutaneous division of bones; (5) sand-bag, or large block with plane surfaces; (6) blunt hooks.

The *chisels* and *osteotomes* employed are those introduced by Sir William Macewen. The chisel has the same form as the ordinary carpenter's chisel. It is square at the end, and has a very sharp edge. It should be made of the finest steel, and be very carefully tempered. The part of the instrument near the cutting edge is alone raised to a great degree of hardness; the rest of the blade is kept softer, so that there shall be no danger of its snapping. The edge is bevelled on one side only, according to the ordinary pattern, and the thickness of the blade at the base of the bevel is about one-twelfth of an inch (Fig. 427). Chisels with unduly thick blades are clumsy, and are apt to splinter the bone.

It is desirable that the blade and the handle be made of one piece of metal ; that the handle be octagonal, for convenience of holding and that the head be rounded, smooth, and projecting, to receive the blows of the mallet.

Macewen's osteotome has a wedge-shaped extremity, and has the outline, as seen sideways, of an attenuated double-inclined plane (Figs. 427 and 428). It is square at the end, has a sharp edge, and is tempered in the same way as the chisel. The precise fashioning of the blade is shown in the full-sized figure (Fig. 427). The handle and the extremity of the instrument are the same as the chisel. Indeed, these two instruments differ only in the manner in which their cutting extremities are bevelled.

They should present various widths of blade, according to the size of the bone to be divided. The most convenient sizes are represented by three instruments, the smallest of which is one-third of an inch wide in the blade and the largest from half an inch to two-thirds of an inch in width. Upon the side of the osteotome a half-inch scale is marked, so that the depth to which the instrument has passed may be noted.

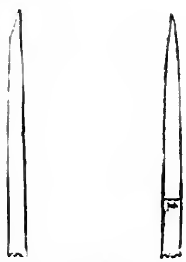

FIG. 427.
SECTION OF CHISEL. SECTION OF OSTEOTOME.
(Both actual size.)

The chisel is used only for paring, shaving, and cutting out wedges of bone, as in cuneiform osteotomy.

The osteotome is employed only for making simple incisions or wedge-shaped openings, but without removal of bone. The chisel, like the ordinary carpenter's chisel, is apt to go awry if a straight section be attempted.

It is well that new instruments should be tried upon the bones of animals before being used in operating upon the living subject, if there be any doubt as to their strength.

In one case, when dividing the femur for deformity following a mal-united fracture, I (F. T.) was horrified to find on removing the osteotome that a large angular piece had been broken from the cutting edge. I was unable to remove the fragment, but the bone united without complication, and no inconvenience followed upon the retention of the piece of steel, which was no doubt buried in the callus.

The *mallet* should be made of metal (lead) throughout, for purposes of sterilisation. The heavier the head the better.

The *saws* used for the subcutaneous division of bone are founded upon Adams's saw. The blade is very slender, and the serrated

edge is of limited extent (Fig. 429). Many saws have been introduced, but they differ very little from Adams's instrument, except in the shape of the handle or in the inclination of the blade to the handle. Trocar saws and concealed saws are ingenious, but are of no especial practical value.

The *sand-bag* or *sand-pillow* is used for the purpose of fixing or embedding the limb during the process of dividing the bone with the osteotome.

The sand-pillow used by Sir William Macewen measures 18 inches by 12 inches. The case is filled with sand just sufficient to enable it to be shifted from one part of the bag to another without leaving any portion empty—a moderate fullness without distension. " The sand is moistened just before the operation, to prevent the escape of dust and to produce greater cohesion between its particles, so that it will more readily retain the form or mould imparted to it. It is then covered with a sheet of jaconet or other waterproof material, and laid on a table " (*Macewen*).

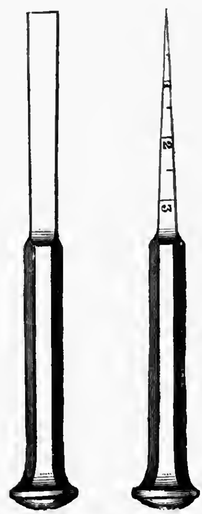

FIG. 428.—MACEWEN'S CSTEOTOME.

A block of metal, such as a leaden weight with rectangular sides, will be found very useful instead of the sand-bag. It should be encased in a sterilised towel, and when placed transversely it forms a good fulcrum on which to complete the fracture of the bone after it has been nearly chiselled through.

A large wooden block, resting on a broad base, and with a narrower upper edge, which is hollowed transversely so that the patient's limb can be conveniently placed on it, answers even better than the leaden block referred to.

The Operation

1. **Linear Osteotomy with the Osteotome.**—This operation cannot be better described than in the terms employed by its author, Sir William Macewen :—

" In order to introduce either the saw or the osteotome, a wound in the soft parts must be made. This wound ought to be a sharp, clean, single incision, produced by one stroke of the instrument whenever this is practicable. Dissection ought to be avoided, the situation in which the incision is to be made being chosen so as to get to the

bone as directly as possible. The direction of the incision should be in a line with that of the muscular fibres about to be penetrated. The situation of the wound in the soft parts ought to be selected so as to avoid cutting not only the larger vessels, but also the smaller ones, when this can be done.

"As to the extent of the incision, this depends greatly on the surgeon, whether he wishes to see what he is doing, or whether he can trust to the tactile sensations conveyed through the instrument to his hand as a sufficient guide. If the latter, the wound need only be large enough to admit the osteotome; if the former, it would require to be a couple or more inches in length, according to the depth of the tissues. When a surgeon commences to practise osteotomy, it would be well for him to make a large incision, one sufficient to enable him to examine the bone with the finger, or even to see the bone. In this way he performs his operation with more confidence, and the extent of his incision is an element of safety, inasmuch as it provides a ready exit for discharge—blood or serum—which otherwise might be pent up in the

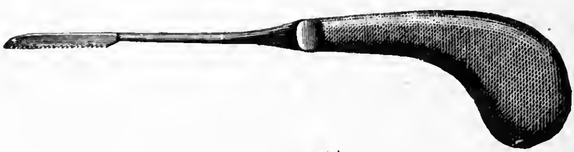

FIG. 429.—ADAMS'S SAW.

parts, causing distension. After he has gained a little more experience, the osteotome may be used as a probe (the saw will never answer this purpose), the sensations conveyed through the instrument being sufficient to enable the operator to ascertain all that can be known by the introduction of the finger. When the operator has reached this stage, all that is necessary is to make an incision which will enable the osteotome to reach the bone—from half an inch to an inch long, according to the breadth of the blade. By operating in this way the tissues are much less disturbed, there is less effusion of blood or serum, and much less need of drainage.

"When small wounds are made, the knife ought to remain *in situ* until the saw or the osteotome is introduced by the side of it to the bone, the knife acting as a guide. When the osteotome has reached the bone, it should be turned in the direction in which the osseous incision is to be made, care being taken while doing this not to denude the bone of periosteum.

"The osteotome ought to be used in such a way as to direct its cutting edge away from any important soft structures which it may

be necessary to avoid. As the osteotome has blunt sides, it may be used to lever the soft tissues aside, keeping meanwhile the cutting edge of the instrument in close contact with the bone.

"After a little practice, the osteotome acts as a probe, and when once the tactile impressions conveyed through the instrument are cultivated, it becomes a delicate indicator of the state of the bone, the precise relation of the osteotome to it, and the extent of the osseous incision. But when the osteotome has been embedded in the bone for an inch or two, its delicacy of touch is lost, and it no longer remains a precise indicator of what is in contact with its cutting edge. This is due to the manner in which the sides of the instrument are pressed on and caught by the bone, the amount of lateral pressure varying according to the amount of the osseous tissue through which the instrument passes.

"This may be easily rectified by introducing a finer instrument by the side of the thicker one first used, and withdrawing the latter. The finer instrument is then placed in the osseous groove made by the thick one; but, being a more attenuated wedge, its sides are not pressed on, so that it acts as an indicator of the kind of tissue in immediate contact with its cutting edge. This can be repeated in a thick bone by the substitution of a third instrument of still greater acuteness.

"When using the osteotome, it ought to be grasped firmly in the left hand, steadied by the inner border resting on the patient's limb. The surgeon ought to cut to, instead of from, himself; thus, if the surgeon is operating on the inner side of the left limb, he ought to stand on the left side of the patient, and cut towards himself.

"If the surgeon, instead of following this instruction, should hold the osteotome loosely, a slightly uneven blow with the mallet would outweigh his grip, and might cause the instrument to slide along the surface of the bone, peeling the periosteum, or causing a more unpleasant accident, such as penetration of an artery.

"When the chisel is placed in position, the mallet may then be brought into requisition, being used by the right hand. When the external shell of bone is felt to have given way, it is not advisable to attempt to complete at once this particular portion of the section, because the instrument is apt to be caught. In order to avoid the impaction, the entire superficial portion of the section ought to be completed in the first instance, so as to permit a little movement of the instrument in the direction of its breadth; and by making a series of such movements, after each impulse given by the mallet, there can be no fixity. The osteotome ought not to be pressed against the bone transversely to its breadth, as it is possible that it may be broken or

twisted by so doing. The bone itself may be splintered longitudinally by such pressure. In no instance should the osteotome or chisel have a breadth greater than the diameter of the bone about to be cut, otherwise the soft structures at either side are apt to be injured." (*See* also the account of Macewen's operation for genu valgum, page 694.)

Comment.—There is no very great merit in a small incision, but at the same time there is no need to make a larger incision in the soft parts than is required for the mere introduction of the osteotome or chisel, and a surgeon would do well not to operate upon the living subject until, by careful practice, he has acquired confidence in himself and in his ability to operate through a small incision.

No tourniquet or elastic band need be employed to render the limb bloodless. While Esmarch's elastic compressor obviously prevents any bleeding during the actual operation, it is certain that it induces a greater degree of oozing when the bandage is removed. There is no operation area to be obscured by blood. The surgeon guides his instrument by his touch and not by his eyes. If an artery should be divided by accident, the sooner the injury is discovered the better. The Esmarch's band merely postpones the discovery until a larger and deeper wound has probably been made, and it is of no assistance in lessening the severity of the lesion.

It should be a rule that the incision in the soft parts should be so placed as to reach the bone by the shortest and safest route and in the most convenient place, and it should be in a line with the section it is proposed to make in the bone. Macewen makes the incision in the soft parts at right angles to the line of the incision on the bone, and, introducing the osteotome, turns it into place after introduction. This complicates matters a little, and although it is quite in accord with the principles of the subcutaneous method, the measure is—with modern antiseptic precautions—quite unnecessary.

The osteotome should, of course, always be so applied as to cut from and not towards the main artery, should it be near the line of section. In one or two positions this is not quite possible, e.g. so far as concerns the upper tuberosity of the tibia and the popliteal artery.

When once the osteotome has cut into the bone, care should be taken that the cut be not lost. If the blade slip or be removed, much time may be wasted and no little damage done in attempting to find again the original cleft in the bone.

2. **Linear Osteotomy with the Saw.**—This operation differs but little from the last, except in the main element that the saw is used in the place of the chisel.

It was originally insisted that the procedure should be subcutaneous, but if proper antiseptic precautions are employed the subcutaneous method may well be replaced by a free incision, which will enable the surgeon to see precisely what he is doing.

The best situation for dividing the bone having been selected, and the part being firmly held, a narrow-bladed knife is passed through the skin down to the bone. The tissues are freely divided so that the bone is laid bare along the line which the saw must travel.

The knife is employed to make a space for the passage of the saw, and the deep incision should not be so incomplete that the saw has to be forced through the tissues.

Before the knife is quite withdrawn the saw should be carefully introduced by the side of it, so as to reach the part of the bone which has been incised. When the saw is in position the knife is withdrawn. A suitable pattern of the Adams saw is employed.

The saw must be used with short strokes, and care must be taken that its tip is not ruthlessly thrust into the tissues upon the opposite side of the bone.

Comparison of the Two Methods.—Of these two methods, that of dividing the bone by means of an osteotome is undoubtedly the better. The saw, it is true, is easier to use, and carries with it the comparative safety which belongs to a blunt instrument. Its use, however, leaves a quantity of bone *débris* in the depths of the wound, which, while it is usually harmless, may yet act as irritant foreign matter. There is considerable risk of lacerating the soft parts around the bone with the tip of the saw, and also with its blade as the section is being completed.

The osteotome, or chisel, on the other hand, is somewhat difficult to use, and while perfectly safe in the hands of an experienced operator, is a dangerous weapon when used by a beginner. The parts are divided by a clean, fine, simple cut. The instrument is not moved to and fro in the line of the wound. There is no bone *débris*, and there should be no laceration of soft parts. The instrument is powerful and of wide application.

3. **Cuneiform Osteotomy.**—In this form of the operation a cuneiform or wedge-shaped piece of bone is removed to remedy an abnormal curve or angular deformity. It has been applied in the treatment of the curved femora and tibiæ resulting from rickets, in some cases of bony ankylosis at an unusual angle, and in a few examples of angular deformity produced by mal-union after fracture.

The exact size and shape of the wedge must be carefully deter-

mined, and must obviously depend upon the position and extent of the deformity.

In general terms, it may be said that the side of the wedge should be at right angles to the axis of the bone respectively above and below the seat of the operation (Figs. 430 and 439). In actual practice, however, so large a wedge-shaped piece of bone is very seldom removed. If the curvature in the bone be not extreme, many surgeons content themselves with a mere linear osteotomy, leaving a gap between the divided ends when the limb has been adjusted, which gap appears to fill up without complication (Fig. 439, C).

In the severer kinds of deformity a wedge may be removed much smaller than is necessary to entirely overcome the deviation, a gap of moderate size being left when the limb has been brought into its normal position upon a splint.

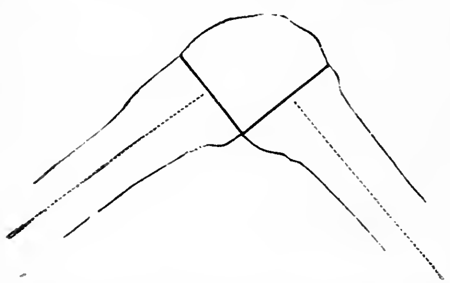

FIG. 430.—DIAGRAM TO SHOW THE LINES OF THE CHISEL-CUTS IN CUNEIFORM OSTEOTOMY FOR ANGULAR DEFORMITY AFTER FRACTURE, ETC.

The wedge, moreover, need not extend through the entire thickness of the bone. It may involve possibly three-fourths of the diameter of the bone, the remaining fourth being bent or broken.

In performing this operation a chisel will be found in most instances to be more convenient than a saw.

In some forms of bony ankylosis of joints, however, the saw may prove to be the more suitable instrument, or both saw and chisel may be used together.

The incision in the soft parts must of necessity be large—as large at least as the base of the intended wedge. It need be no larger, since the skin can be displaced in one or other direction according to the position of the chisel. As soon as the bone is exposed, the periosteum must be divided and carefully separated with the elevator. In dividing the bone the chisel should be employed and not the osteotome. The instrument must be so held that the straight edge is towards the bone to be left, and the bevelled edge towards the portion to be removed.

If a large wedge has to be removed, it should be dealt with in sections. A small wedge-shaped piece should be first taken out, and then thin slices of bone should be shaved from each side of the exposed

bone until a cuneiform cavity of the desired size and shape has been produced.

If an attempt be made to remove a large wedge at once, it will be found that the chisel is apt to go awry, to incline towards the straight edge, and in consequence an uncertain division of the bony tissue is made. There is apt to be free oozing as the cancellous tissue is being cut through. It is not well to attempt to prise out the wedge of bone with the chisel. The bone so treated is apt to split, or the chisel may be broken. The wedge can be removed better with forceps aided by an elevator. After the bone has been dealt with, the periosteal flaps may be brought together by a few fine catgut sutures. The skin wound should not be too completely closed, but room left for drainage. A small dressing of sterilised gauze and wool is then firmly applied by means of a bandage. No especial observations need be added with reference to cuneiform osteotomy performed with the saw.

Osteotomy with resection is carried out when the difference in length of corresponding long bones is very marked and threatens to produce incurable deformity, such as lateral curvature of the spine. It has to be contrasted with the provision of some artificial means of increasing the length of the shortened bone or limb. Sometimes the shortening has resulted from arrest of epiphysial growth in a bone, sometimes from badly united fracture, or from joint disease. Osteotomy with resection is only suitable for a small proportion of the cases, almost entirely in young subjects, and the possibility of non-union resulting even in them must be borne in mind before resorting to it. It may be illustrated on the femur, where the other limb is two inches shorter. A straight incision, four inches long, is made on the outer aspect of the femur, about the centre of the bone. This incision goes right through the periosteum, which is then carefully reflected for over two inches from the whole circumference of the bone. Especial difficulty will be met with in doing this at the linea aspera. Two inches are then measured off and marked by drill-punctures on the bone; above and below these points the drill is made to penetrate its whole thickness, so as to enable silver wire to be subsequently introduced. It is far easier to make the perforations for the wire before than after the bone is cut across. The required amount is now removed by means of a so-called Gigli's saw (which is simply a strong fret-saw used like a chain-saw). The first section is not completed until the second one has been cut through. The silver wire is now introduced, the loop tightened up so as to bring the two ends in accurate apposition, and the loop is buried, if possible, under the sutured periosteum. The wire is left permanently in. It will be noted that the

muscles will have to shorten considerably, and if many inches of bone are removed a good result can hardly be expected.

Osteotomy with resection is sometimes performed in cases of arrest of growth in one of two long bones placed side by side, i.e. the bones of the leg or forearm, due to former injury to the epiphysial line of cartilage. In such a case the injured bone has stopped growing whilst its companion one has pushed the hand or foot over. It is then advisable to make the resection include the corresponding epiphysial disk as well as a certain amount of the shaft of the bone.

After-treatment.—The after-treatment of osteotomy cases is very simple. The case is one of compound fracture made in the most favourable circumstances.

The limb must be put up in a suitable splint which will correct the deformity, keep the divided ends of the bones in close apposition, and maintain the limb at absolute rest. As many of the patients are children, the selection of a proper splint is a matter of moment.

The time during which the limb must be kept adjusted upon the splint will correspond to the time required for a simple fracture of the same bone to consolidate. Indeed, the after-treatment is essentially that observed in cases of fracture.

It should be noted that throughout the operation the strictest precautions should be carried out as to asepsis. The bone to be divided is often very dense, and in the various manipulations of the limb some flaw in asepsis is apt to occur. The surgeon should wear sterilised gloves, and the patient's limb should be encased with sterilised towels.

Results.—The results of osteotomy operations may be said to be in every way excellent. Since the methods of operating have been more precise, and since antiseptic and aseptic measures in the treatment of the wound have been introduced, the risk attending these operations has been reduced to an insignificant figure. Indeed, the commoner osteotomies may be said to be practically devoid of risk.

Osteotomy for Faulty Ankylosis at the Hip

This measure is carried out in certain cases of rigid ankylosis of the hip-joint, resulting from disease, in which the limb has assumed a faulty position and all milder methods of treatment have failed. In the most usual deformity the thigh is flexed, adducted, and a little rotated in. The object of the operation is to bring the limb straight. The possibility of securing a movable joint at the same time may or may not be contemplated by the operator.

1. **Supratrochanteric Osteotomy.**—This operation may be performed either with the saw or with the osteotome. Of the two we certainly recommend the osteotome.

As a rule, the most convenient aspect on which to attack the bone is the anterior, towards its upper part. The same route, between the sartorius muscle in front and the tensor fasciæ femor is behind, is that usually selected for excision of the hip. Special conditions may lead the operator to select the upper aspect of the femoral neck—in this case the incision is made from below the anterior superior spine towards the top of the great trochanter. A considerable mass of muscle—gluteus medius and minimus—will have to be traversed before the capsule is reached. The muscles are to be divided parallel to their fibres, but it is well to cut the capsule somewhat transversely to the femoral neck, in order to give the chisel or saw sufficient room to work. Stout metal retractors should be used.

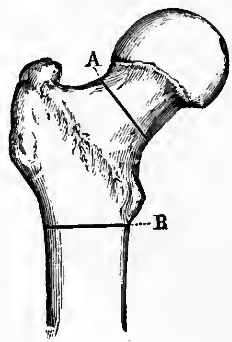

FIG. 431. — OSTEOTOMY FOR FAULTY ANKYLOSIS OF THE HIP.

A, Intracapsular; B, Extracapsular.

If the anterior incision be selected the wound is made for about three inches, downwards and slightly outwards, from the anterior superior spine. The depth to be traversed is not so great as by the superior incision. It is a good plan to guard the penetration of the osteotome by a curved elevator, which is placed on the further side of the femoral neck and held there by an assistant.

This is especially advisable if the neck is attacked from above, as just below the inner part of the capsule run the internal circumflex artery and vein, which would give rise to serious hæmorrhage if wounded by an accidental slip of the chisel. Another point should be emphasised, that of the right direction of the cut. It is easy to make it too oblique and thus encroach upon the shaft.

We have not described the original subcutaneous operation of the late W. Adams (Fig. 431, A), since although successful in his hands and those of others, it was not free from risk, the whole work being done in the dark. The open method with asepsis has replaced it, as in so many other operations and regions of the body.

2. **Infratrochanteric Osteotomy.**—Either the saw or the osteotome may be employed, or both.

Operation.—The osteotomy is carried out precisely as in the procedure just described.

The incision is longitudinal, is placed over the outer aspect of the femur and about at the level of the lesser trochanter.

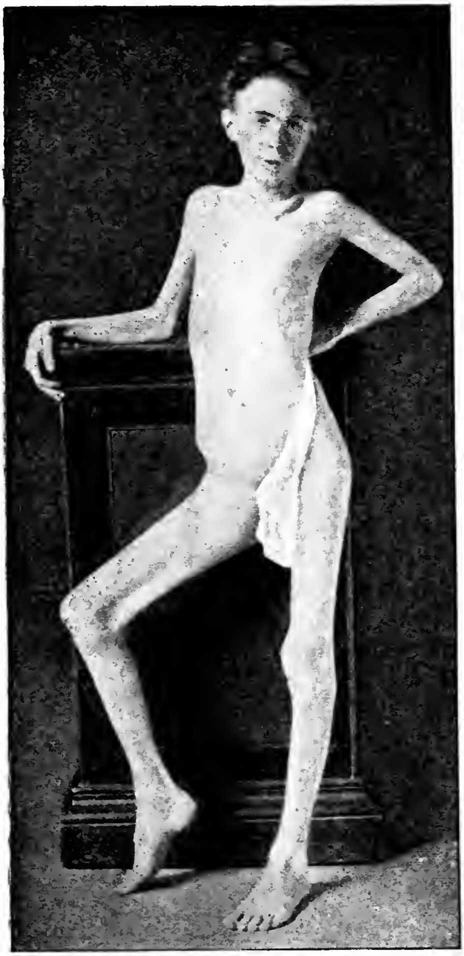

FIG. 432.—OLD PATHOLOGICAL DISLOCATION OF RIGHT FEMUR INTO THYROID FORAMEN WITH ANKYLOSIS, TREATED BY OSTEOTOMY (SEE FIG. 433).

Note extreme tilting of pelvis, which conceals the amount of deformity (flexion to at least 90 degrees and abduction) at the hip-joint.

The osteotome is introduced, and the bone is divided immediately below the lesser trochanter and in a line at right angles to the shaft of the femur (Fig. 431, B).

Comment. — In these situations the bone should be divided completely. It should not be partially cut through and then fractured, lest dangerous splinters of bone be produced. The assistant, therefore, should be careful how he holds the limb, and how he brings pressure to bear upon the parts which are being divided.

Splinters of bone resulting from section of the neck of the femur have been driven into adjacent arteries, and serious bleeding has resulted. (Jacobson's "Operations of Surgery," 1902, vol. ii., page 723.)

As to the instrument to be used, reasons have been already given (page 685) for preferring the osteotome to the saw, and to operations in this region the same criticisms apply.

In severe and old-standing cases the mere division of the bone may possibly not suffice to correct the deformity, and it may be necessary to cut contracted tendons or

contracted bands of fascia. The tendons most usually in need of tenotomy are those of the adductor longus, rectus, and sartorius.

Of the two methods described—viz. that of division of the neck and that of division of the shaft—the latter may be said in general terms to be the better. It is certainly the simpler and the easier operation. It has been asserted that the infratrochanteric operation leads to more shortening, but the statement does not appear to be well founded, and shortening is largely a question of after-treatment.

FIG. 433.—RESULT OF OSTEOTOMY OF FEMORAL NECK FOR PATHOLOGICAL DISLOCATION (SEE FIG. 432).

Extension is now normal, and there appears to be no shortening, but a slight degree is concealed by tilting of the pelvis.

Division of the femoral neck is most applicable to cases in which it has remained unaltered, e.g. in ankylosis after rheumatic fever. In many instances of ankylosis due to tubercular disease, there is practically no neck to the bone, or there is an immense mass of thickened tissue in the position of the old capsule, or the head of the femur has been displaced upon the dorsum. The use of the X-rays will always tell the surgeon whether the neck still exists, and is suitable for division. It should be noted that if the ankylosis has been due to tubercle there is strong reason for avoiding the supratrochanteric operation, as it will involve opening up diseased areas of capsule and bone, and probably lighting up the trouble again.

After division of the neck considerable deformity may still persist, owing to extreme contraction of the psoas and iliacus muscles.

Cuneiform osteotomy is occasionally performed in this region;

and for the relief of coxa vara, or sinking and shortening of the femoral neck, elaborate methods have been devised by Mr. Keetley and others—including the separation of the great trochanter and wiring or pegging the femoral neck in a more vertical position. Cases differ so much that the details must be left to the surgeon, but it may be noted that in moderate degrees of coxa vara it is best not to operate, and that in the more severe cases the results have not as a rule been very good.

(Consult paper by Mr. Keetley in the "New. Syd. Soc. Atlas of Pathology," under "Coxa Vara.")

Osteotomy for Genu Valgum and for Faulty Ankylosis of the Knee-Joint

GENU VALGUM

Anatomical Points.—In the severer forms of genu valgum—and it is in these only that osteotomy is practised—there is a great increase in the size and depth of the internal condyle. This is due to an increase in the diaphysis of the bone rather than in the epiphysis (Fig. 434).

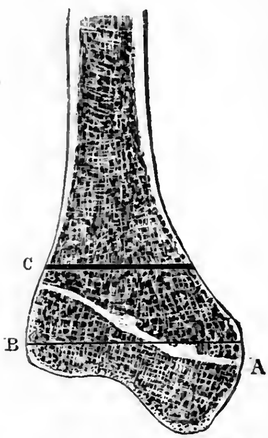

FIG. 434.—VERTICAL SECTION OF THE LOWER END OF A DEFORMED FEMUR, FROM AN EXTREME CASE OF GENU VALGUM.

A, Line of epiphysis; B, Transverse line drawn at level of adductor tubercle; C, Line of Macewen's operation.

The position and limits of the lower epiphysis of the femur are dealt with in the chapter on excision of the knee. It is only necessary here to repeat that the epiphysial line is about on a level with the tubercle for the adductor magnus tendon. The trochlear surface of the femur belongs to the epiphysis.

A transverse section of the femur about the epiphysial line will show that the outer part of the bone is much more extensive than the inner part (Fig. 435), and this disproportion is continued for some little distance upwards in the less expanded part of the bone. The medullary canal ceases some way above the point at which the shaft of the bone widens out to form the condyloid extremity. Indeed, none of these operations concern the canal.

The synovial membrane of the knee-joint extends upwards as a large cul-de-sac above the patella and beneath the extensor tendon. This cul-de-sac is somewhat triangular, has its base at the condyles and its narrowest part uppermost, and

reaches a point an inch or more above the upper margin of the trochlear surface of the femur. When the knee is bent, the cul-de-sac is drawn down.

Above the synovial pouch is a bursa, which communicates with the knee-joint in about seven cases out of ten.

In certain of these operations the position of the anastomotica magna artery must be borne in mind.

The following operations will be described:

1. Osteotomy of the shaft of the femur from the outer side.
2. Macewen's supracondylar operation.

1. **Osteotomy of the Shaft of the Femur from the Outer Side.**—The patient lies upon the back, with the knee flexed over the wooden block or sand-bag, upon which the limb is made to rest securely. The surgeon should stand to the inner side of the limb, i.e. between the patient's legs. An assistant standing opposite to him steadies the limb.

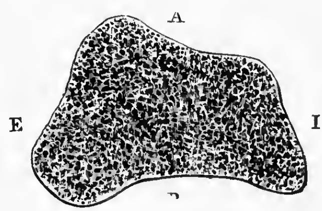

FIG. 435.—TRANSVERSE SECTION OF THE FEMUR ABOUT THE LEVEL OF THE EPIPHYSIAL LINE, SHOWING THE TRIANGULAR OUTLINE OF THE BONE.

A, P, E, I, Anterior, posterior, external, and internal surfaces.

The thigh being adducted so as to expose well the outer surface to the operator (as he stands to the inner side of the knee-joint), an incision about one inch in length is carried down to the bone at a point about two inches above the external condyle. The incision is made upon the outer side of the thigh, is transverse—i.e. at right angles to the long axis of the femur—and may be made in one cut. The knife passes through the ilio-tibial process of the fascia lata, and runs in front of the biceps muscle.

When the knife is withdrawn the osteotome is inserted, and the limb—no longer adducted—is firmly planted upon the sand bag. The osteotome is made to traverse the shaft transversely. As the outer part of the bone is here thicker than the inner part, it will be found that when two-thirds of the shaft have been divided the bone can usually be quite readily fractured. It is essential that the division be extensive enough, and that no premature and violent attempts be made to complete the division of the bone.

Comment.—This operation is simple, although the position of the surgeon is a little inconvenient. The bone is divided at a much narrower part than in the supracondyloid operation next to be described; the osteotomy is therefore easier and more quickly performed. There

is no danger of the chisel wandering into the wide expanse of bone which makes up the external condyle. The bone section is far removed from the epiphysial line, and is also at a distance from the synovial sac of the knee-joint. No blood-vessels of any importance come in the line of the incision.

2. **Macewen's Supracondyloid Operation.**—The patient lies upon the back, close to the edge of the table. Both hip and knee are flexed; the thigh is adducted and rests upon its outer side. The knee is well fixed upon the sand-pillow. The surgeon places himself upon the outer side of the limb. One assistant, standing upon the opposite side of the table to the operator, steadies the limb by the thigh, while a second assistant at the foot of the table takes hold of the upper part of the leg.

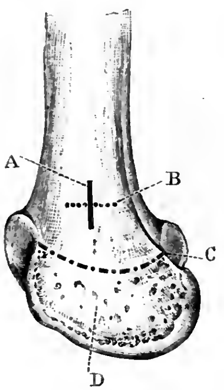

FIG. 436. — MACEWEN'S OPERATION FOR GENU VALGUM.

A, Skin incision; B, Osteotome incision; C, Epiphysial line; D, Inner condyle.

The following is Macewen's description (Heath's "Dictionary of Surgery," vol. ii., page 143):—

"A sharp-pointed scalpel is introduced on the *inside* of the thigh, at a point where the two following lines meet—one drawn transversely, a finger's-breadth above the superior tip of the *external* condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon. The scalpel here penetrates at once to the bone, and a longitudinal incision (A, Fig. 436) is made, sufficient to admit the largest osteotome and the finger should the surgeon deem it necessary. Before withdrawing the scalpel, the largest osteotome is slipped by its side until it reaches the bone.

"The scalpel is withdrawn, and the osteotome, which was introduced longitudinally, is now turned transversely in the direction required for the osseous incision (B, Fig. 436). In turning the osteotome, too much pressure must not be exerted, lest the periosteum be scraped off. It is then convenient to pass the edge of the osteotome over the bone until it reaches the posterior internal border, when the entire cutting edge of the osteotome is applied, and the instrument is made to penetrate from behind forwards and towards the outer side.

"After completing the incision in that direction, the osteotome is made to traverse the inner side of the bone, cutting it as it proceeds, until it has divided the uppermost part of the internal

border, when it is directed from before backward towards the outer posterior angle of the femur.

" In cutting on these lines there is no fear of injuring the femoral artery. The bone may be divided without paying heed to this order of procedure, but it is better that the operator should have a definite plan in his mind, so that he may be certain as to what has been divided and what remains to be done. The writer is persuaded that accidents have happened by not paying heed to this. In using the osteotome, the left hand, in which it is grasped, ought to give, after each impulse supplied by the mallet, a slight movement to the blade—not transversely to its axis, but longitudinally—so as to prevent any disposition to fixity which it might assume.

" After the inner portion of the bone is divided, a finer instrument may be slipped over the first, which is then withdrawn; and even a third, if necessary, may take the place of the second when the outer portion of the bone comes to be divided. Whether one or more osteotomes be used depends much on the resistance met with. If the tissue is yielding, one may suffice; if hard or brittle, two or three will effect the division more easily and with less risk of breaking or splitting the bone longitudinally. In the adult the dense circumferential layer of bone resists the entrance of the osteotome at the outset, but several strokes cause the instrument to penetrate this superficial dense portion, when it will pass easily through the cancellated tissue.

" After a little experience, the surgeon recognises, by touch and sound, when the osteotome meets the hard layer on the outer aspect of the bone. If it be considered desirable to notch or penetrate this outer dense part of the bone, in doing so the osteotome ought to be grasped firmly by the left hand, the inner border of the hand resting on the limb, so as to check instantly any impetus which may be considered too great. It is better to snap or bend this layer rather than cut it.

" When the instrument is to be altered in position, it ought not to be pulled out in the ordinary way, as it is then liable to be removed from the wound in the soft parts, as well as from the bone. Instead, let the left hand, with its inner border resting on the limb, grasp the instrument, while the thumb is pressed under the ridge afforded by the rounded head, and gently lever the osteotome outwards by an extension movement of the thumb. In this way the movement may be regulated with precision. It is desirable to complete all the work intended by the osteotome before removing it from the wound.

" When the operator thinks that the bone has been sufficiently

divided, the osteotome is laid aside and a sponge saturated in 1-40 carbolised watery solution is placed over the wound. While the surgeon holds the sponge, he at the same time employs that hand as a fulcrum ; with the other he grasps the limb lower down, using it as a lever, and jerks if the bone be hard, or bends slowly if the bone be soft, in an inward direction, when the bone will snap or bend, as the case may be."

One or two silkworm-gut sutures are usually required. If a plaster of Paris case be applied, these sutures may be left without the least apprehension for the six weeks or so that the splint is worn. The proof that the operation is successful lies in the fact that the internal malleoli can be made to touch each other easily while the knees are kept extended.

For the after-treatment, *see* previous chapters.

Comment.—The highest part of the articular surface of the femur is a good guide to the level of the lowest part of the incision. Great care must be taken that the line of the bone-incision is appreciated and accurately followed. In normal limbs—as Macewen points out—a line drawn transversely across the bone from the adductor tubercle will pass into the middle of the external condyle, whereas in the femur, in a case of severe genu valgum, such a line would pass into the upper part of that condyle (B, Fig. 434). If the osteotome be not carefully directed, it is apt to land in the wide tract of bony tissue forming the outer condyle.

Again Sir Wm. Macewen writes : "For a short distance above the condyles the femur has a much thicker outer than inner border ; in many instances the outer is twice as thick as the inner. If the form of the bone be not borne in mind, the surgeon may think that he has divided it sufficiently, and yet he may find that it will not yield, owing in most cases to the posterior outer part remaining intact."

In young subjects up to fifteen or sixteen, the division of the internal two-thirds of the bone will usually suffice, the remainder being broken ; but in adults, especially when the bone is hard and brittle, the section should be more complete, and as little fracturing should be attempted as is possible.

In children one osteotome will suffice for the division of the bone. If care be not exercised, it is possible for the femur to be split longitudinally. The incision employed is above the level of the articular ligaments.

The cut in the soft parts may be made transversely, and be so placed as to correspond to the intended bone-incision. By this means the osteotome is more readily introduced and more easily re-inserted

should it be accidentally removed during the operation. The transverse incision spares the soft parts from a certain amount of bruising and disturbance, but it does not favour so complete a subcutaneous method.

Although the synovial pouch of the knee-joint reaches as high as the level of the bone-incision, it is not in the way of the actual wound itself, since it tapers to the middle line as it ascends. A certain amount of fat intervenes between the synovial pouch and the bone, and the osteotomy cut is posterior to the pouch.

There is but little bleeding. The femoral artery cannot be in danger. If the knee be well flexed, the popliteal vessels are placed as far as possible away from the operation area. The wound is above the superior internal articular artery, and below and anterior to the

FIG. 437.—LARGE PEDUNCULATED EXOSTOSIS GROWING FROM THE FRONT OF THE FEMUR.

In this case the incision passed through the quadriceps in the long axis of limb, the peduncle being cut through with a broad chisel flush with the surface of the femoral shaft. A perfect result was obtained.

anastomotica magna. Bleeding from this vessel has, however, been reported as occurring during the operation.

In making the surface-wound, branches of the internal cutaneous nerve can scarcely be avoided, and some tributaries to the internal saphenous vein may be cut. The incision is anterior to the inner series of tendons about the knee, and the least amount of injury is inflicted upon the soft parts, so far as actual cutting is concerned, when the incision is longitudinal, as described in the account of the operation.

With regard to the two operations described—viz. osteotomy of the shaft and Macewen's operation—the points which have been urged in favour of the former procedure have been detailed in the comment made upon that measure. The special advantages which

are claimed for the supracondylar osteotomy are these: The bone is divided nearer to the seat of the deformity, and the sections of bone left by the osteotome are sufficiently wide to allow of their being brought well together and kept in safe contact during the progress of the after-treatment.

The Removal of Exostoses.—This operation, so far as the long bones are concerned, is usually a very simple one. Frequently the exostosis has a narrow pedicle or attachment, and the surgeon should aim at exposing this by his incision, and should cut it through with a chisel level with the bony surface from which it grows.

Fig. 437A shows an unusually large bony growth from the front of

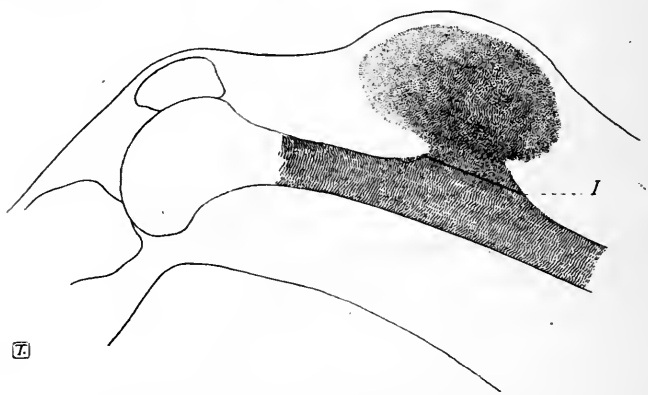

FIG. 437A.—RADIOGRAPH OF CASE SHOWN IN FIG. 437.

the femur, and the dark line I indicates the division made with the chisel. Care should be taken to injure the overlying or adjacent structures as little as possible, and when the exostosis is situated near a joint, the latter should not be opened, if this can be avoided. Unless exostoses interfere with the use of a limb or press upon an important nerve, they are as a rule best left alone. Ivory exostoses growing from the orbital or bones of the skull present special difficulties owing to their extraordinary hardness, and operation upon them is so very rarely called for that a further description seems unnecessary here.

FAULTY ANKYLOSIS OF THE KNEE-JOINT

This operation is carried out in cases of osseous ankylosis of the knee in which the deformity is considerable, in which a less complete measure would be ineffectual, and in which no active disease is present.

It is not likely to be required unless the angular deformity approaches a right angle, and the fact that bony union has occurred should be established by radiographic evidence before operation. Deformity due to fibrous ankylosis, however advanced, can usually be overcome by weight extension aided by tenotomy.

Comment.—If the deformity be such that the femur and tibia form nearly a right angle with one another, then it is improbable that mere linear osteotomy of the femur will suffice to correct the deviation.

In such a case it may be necessary to remove a wedge from the anterior surface of the femur, or to carry out a double linear osteotomy, as Macewen advises—viz. the division of the femur as above described, and a division of the tibia just below its tuberosities (page 700).

We have operated on a fair number of these cases, which present a most difficult problem to the surgeon. We have obtained the best results from a true excision of the ankylosed joint. This does not leave an awkward angle, as the previously described methods do. The incision of the wedge is illustrated in Fig. 430, and the operation is described on page 686.

FIG. 438.—BONY ANKYLOSIS OF KNEE AT A RIGHT-ANGLE IN A GIRL OF 12, AFTER TUBERCULOUS DISEASE.

In these cases of extreme deformity great care must be taken in extending the limb after the operation. The tissues of the popliteal region will be much contracted, and a gradual straightening of the limb, extending over a week or more, and associated possibly with the division of certain tendons and bands of fascia, will be advisable. In general terms, it may be said that the limb may be extended with safety so long as the tibial arteries pulsate freely at the ankle.

As soon as the wound is soundly healed and the limb straight, a plaster of Paris case may be applied.

Osteotomy of the Tibia

Under this title three operations will be described:

1. Linear osteotomy just below the tuberosities.
2. Linear osteotomy for bent tibia.
3. Cuneiform osteotomy for bent tibia.

1. Linear Osteotomy of the Tibia just below the Tuberosities. —This operation is carried out in the treatment of exceptional cases of faulty ankylosis of the knee-joint, as mentioned in the previous chapter.

Operation.—The leg is firmly fixed upon the block or sand-pillow, with the anterior surface well exposed. In every case the surgeon stands to the outer side of the limb to be dealt with.

A spot is selected just below the tubercle of the tibia, and a transverse incision of the necessary width is made over the anterior tibial

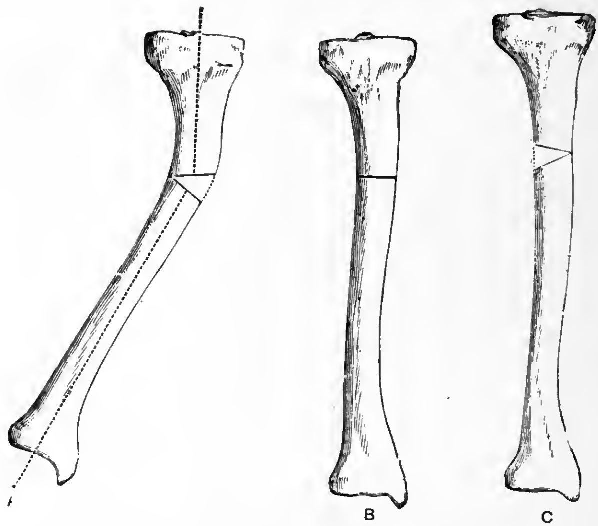

FIG. 439.—Diagram representing a curved tibia—A, with a wedge removed for the purpose of straightening the bone; B, the same with the bone straightened; C, the same with the bone simply divided and straightened. (*Modified from Little.*)

border. The osteotome is then introduced and the bone divided transversely.

The instrument attacks first the anterior aspect of the bone, and then follows the internal surface until the posterior aspect is reached. The inner segment of the bone having been thus divided from before backwards, the instrument is now so directed as to cut from within outwards. In this way all the bone may be divided with the exception of its posterior lamellæ, which are fractured by pressure applied in the antero-posterior plane.

Great care must be taken of the tissues which skirt the external surface of the tibia. They should be guarded by a metal elevator held by an assistant. If this elevator be introduced between the

bone and the periosteum, and if it be securely held during the work of the chisel, no risk is run.

The great vessels at the back of the limb are well protected by the popliteus muscle and the fascia which covers it, although in cases of long-standing ankylosis the muscle will be much atrophied.

The fibula does not require to be divided.

2. **Linear Osteotomy for Bent Tibia.**—This operation will suffice for the larger proportion of cases of bent tibia. Mr. Jacobson considers it to be especially applicable to cases in which the bone is bent laterally, and in which the bend is most marked at the junction of the middle and lower thirds.

The section of the bone is most usually transverse (Fig. 439).

Mr. Barker advises an oblique division of the bone. The plane of the oblique line of section must vary with the direction of the tibial curve. If convex inwards, the bone is divided from above downwards and from before backwards; if curved forwards, the plane of section should be from above downwards and from within outwards. It is maintained that these lines of section permit the deformity to be corrected with the least possible displacement of the fractured surfaces.

Operation.—If the osteotome be employed, the procedure is carried out in the manner already described, the situation of the incision depending upon the position of the bone section. The site of the nutrient canal of the tibia with its large blood-vessel must be borne in mind. In all but very exceptional instances the bone section will be found to be below the site of the canal. The nutrient artery runs downwards in the bone.

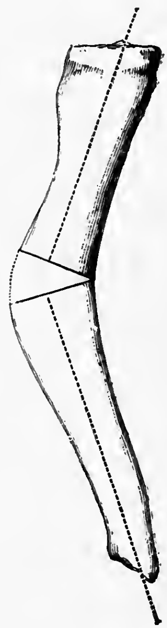

FIG. 440.—CUNEIFORM OSTEOTOMY FOR CURVED TIBIA.

3. **Cuneiform Osteotomy for Bent Tibia.**—This operation is carried out in the manner already described (pages 685-87). The base of the wedge will usually correspond to the crest of the tibia (Fig. 440), and will measure about three-quarters of an inch in breadth.

Cuneiform Osteotomy for Inveterate Club-Foot

In this operation a wedge-shaped piece of bone is removed from the outer side of the foot at the site of the mediotarsal joint.

The cases selected for this method of treatment are examples of very extreme and intractable club-foot, which have resisted treatment by tenotomy, manipulation, and apparatus, which are associated with distinct changes in the shapes of the tarsal bones, and in which it is evident that no step short of the removal of osseous tissue can alter the shape of the foot.

The choice then lies between excision of the astragalus and the operation about to be described. Both give excellent results as a rule, but where talipes equinus has been long associated with the varus, as it frequently is, we believe that excision of the astragalus best overcomes the deformity. This was the opinion of most of the surgeons who spoke in the debate on the subject at the Belfast meeting of the British Medical Association, 1909. As to the relative difficulty of the operation, excision of the astragalus is probably the easier of the two. For the operative details see page 756. We would emphasise the fact that wedge-osteotomy in bad cases of simple varus has given excellent results.

The rudiment of the present operation dates from 1854, in which year Dr. Little suggested the excision of the cuboid in severe talipes equino-varus, and Mr. Solly performed the actual operation involving the removal of that bone (*Med.-Chir. Trans.*, 1857, page 118). Mr. Davies-Colley removed a wedge-shaped piece of the tarsus in 1878, but with Mr. Davy must rest the credit of having formulated the present operation, and of having illustrated it by a number of cases (*Med.-Chir. Trans.*, 1885, page 139).

The Size of the Wedge.—The dimensions of the portion of bone removed must of necessity depend upon the degree of the deformity. In talipes equino-varus the base of the wedge is at the outer side of the foot, and is mainly represented by the cuboid ; the apex will be at the scaphoid bone, the distal side of the wedge will be represented by a line at right angles to the metatarsal bones, and the proximal side by a line at right angles to the long axis of the os calcis.

An important addition to the removal of the wedge consists in a simple division of the neck of the astragalus, performed through a separate incision on the inner side of the latter. Perfect position of the foot can be secured by this combined operation.

In some instances the wedge is composed of portions of the astragalus, os calcis, scaphoid, and cuboid, the last-named bone predominating. In rarer cases it is found to contain portions of every one of the tarsal bones and the bases of the four outer metatarsal bones also.

In talipes equinus the base of the wedge is on the dorsum of the foot and its apex in the sole. The bones represented in the wedge are portions of the os calcis, astragalus, scaphoid, and cuboid; and in severe cases portions of the bones anterior to the two last named may find their way into the wedge.

In removing a wedge of ordinary dimensions no important muscular attachments are concerned. Slips from the tibialis posticus will have to be severed, and the origin of the flexor brevis hallucis detached from the cuboid. The latter muscle will probably be represented by atrophied tissue.

Operation for Talipes Equino-Varus.—The patient is placed upon the back, with the hip and knee a little flexed, and the sole of the foot resting upon a sand-pillow on the table. The surgeon stands to the outer side of the limb, and an assistant opposite to him grasps the foot and leg, and steadies the extremity or moves it as required. The operation (Fig. 441) is usually carried out as follows:

The outer surface of the foot having been well exposed, and the cuboid defined, an oval piece of skin is excised from the outer side of the foot over that bone. The long axis of the oval will be in the long axis of the foot, and will be equal in extent to the base of the wedge of bone to be removed. This piece of skin will include the mass of thickened epidermis and the bursa which are usually found over the cuboid.

It is unnecessary to make an internal incision unless a saw is to be used, but this is not a matter of importance, and we therefore describe the second incision.

The inner side of the foot is now exposed, and at the "stereotyped crease of skin," and in a line over the astragolo-scaphoid joint, a vertical cut is made (from dorsum to sole) of sufficient length to include the thickness of the scaphoid bone. At this incision will fall the apex of the wedge; its base is represented by the part from which the skin has been already removed.

The foot is now firmly fixed so as to bring the dorsum well into view, and with an elevator the tendons and all the soft parts are raised from the dorsum of the tarsus. The elevator is introduced through the outer incision, and the surgeon works from without inwards. The instrument must be kept close to the bone, and the area to be represented by the wedge must be laid entirely bare. This is comparatively easy on the dorsal aspect of the tarsus, but much more troublesome on the plantar one. Farabeuf's rugines are very useful for the purpose, aided by the knife.

FIG. 441.—EXTREME TALIPES VARUS, WITH DEFORMITY OF BONES OF TARSUS.

The black line indicates the outer incision, the dotted lines the wedge of bone to be removed.

Curved directors or slender metal spatulæ are now introduced between the bones and the soft parts which have been raised from the tarsus above or below. When the bones are well cleared the osteotome is made to cut out a wedge-shaped piece. Some surgeons recommend that the section should be made with a key-hole saw, but a chisel is much more convenient. In most of the cases the distal bone-incision has traversed the cuboid and the proximal one the neck of the os calcis. The apex of the wedge is at the scaphoid. If the wedge does not include the head of the astragalus it is often wise to make a separate section of the neck of this bone. It is well known that the altered neck is a great obstacle to restoration of the deformity. In the operation this must be overcome without any tension remaining.

The wedge is now seized with lion forceps, and is loosened. As the surgeon drags upon it with the left hand, he clears the plantar surface of the bones to be removed with a narrow scalpel or with curved scissors. The wedge can usually be lifted out in

one piece. Any hæmorrhage having been dealt with, the portions of the foot are brought together; and if the deformity be not fully corrected, the neck of the astragalus should be divided transversely through an incision made on the inner side.

The large gap should now be well washed out by a stream of sterilised water.

The wounds are closed with sutures, and a drain may be introduced into the lower part of the external wound.

It is not necessary that the bones be sutured together. The limb is finally placed upon a suitable splint, a back-splint with two side-splints—the outer one having an interruption—such as would be employed in the treatment of a compound fracture of the foot. A large sterilised sponge dusted with boric acid forms a suitable first dressing. There will probably be much oozing at first. Primary healing may be anticipated.

A drainage-tube should be kept in for a day or two.

As soon as the wound has healed the foot and leg should be fixed in absolutely correct position in a light plaster-of-Paris case. After this has been removed the case should be kept under observation for some months to prevent any tendency to recurrence of deformity.

Union should be firm in six or eight weeks.

All the patients reported upon have been enabled to walk and perform the daily routine of work, and have become absolutely plantigrade. A useful but slightly shortened foot results. Movement in the ankle-joint may be lost.

The Open Operation for Club-foot.—This operation was devised to secure complete division of all the structures which maintain the contraction in severe club-foot, including the skin and fascia, the tendons of the tibialis anticus and posticus, and the ligaments on the inner aspect of the ankle-joint. It was first advocated by Mr. Phelps in 1881, and since then has been performed in many hundreds of cases. Although it does not involve osteotomy, this operation is advocated by some in cases which would otherwise be treated by cuneiform resection. Hence it may be considered in this section.

The incision is placed exactly in the deep fold of skin which crosses the foot about the level of the midtarsal joint, commencing just outside the tendon of the tibialis anticus and ending at the junction of the inner third and outer two-thirds of the plantar surface, below

the head of the astragalus (*see* Fig. 442). The internal saphenous vein is thus exposed and divided between two ligatures ; branches of the internal saphenous and musculo-cutaneous nerves are cut across. The tibialis anticus tendon is then completely severed ; following this, the abductor hallucis and corresponding part of the plantar fascia. The assistant, by steady eversion of the foot, makes the wound gape fully, and the internal lateral ligament of the ankle-joint is divided so far as it prevents reduction, together with the tibialis posticus tendon close to its insertion. At the end of this extensive section the foot should be forcibly straightened, all bleeding points secured, and the wound filled with moist sterilised or antiseptic gauze. If equinus persists, the tendo Achillis should be divided subcutaneously. An outside Sharp's splint for the foot and leg is then applied, and the gauze dressing reapplied from time to time until healing by granulation is completed. This always takes several weeks, and the resulting scar is usually thick and conspicuous, though it is asserted that it rarely causes discomfort. It is needless to say that the patient should be supervised for at least a year after the operation, to prevent any recurrence of the deformity. In at least 10 per cent. of the cases Phelps was obliged to resort to some form of tarsectomy or tarsotomy.

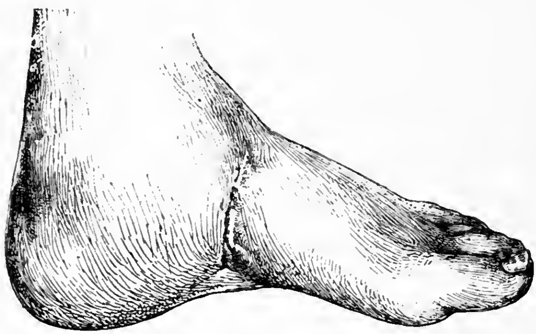

FIG. 442.—SUCCESSFUL RESULT OF PHELPS'S OPEN OPERATION FOR CLUB-FOOT.

The vertical scar is thick, and lies in a deep furrow.

A modification of the open section (Kellock) is perhaps worthy of trial should the surgeon select this method ; a flap of skin and fascia is shaped from the dorsal tissues and moved over to the inner side to fill the gap produced by Phelps's section. The flap (which has its pedicle towards the ankle) is then secured in place by sutures, and the other wound made is also sewn up in great part.

Comments on the Operation.—It appears that many American orthopædic surgeons, including, of course, Mr. Phelps, are still enthusiastic in its favour. Some English authorities, such as Mr. Edmund Owen, endorse its value ; others condemn it strongly, and state that no cases are so hopeless as those which have relapsed after Phelps's

operation. Its drawbacks, as compared with the subcutaneous method, are obvious. There is a large wound to granulate up, and the scar resulting compares very unfavourably with the complete absence of scar after subcutaneous operation. On the other hand, the foot is not shortened, as after tarsectomy. Open section could never be required in the early stage of club-foot, and should not be performed on infants. It may be useful in cases which have resisted subcutaneous division of tendons and ligaments, and in those in which tarsectomy would otherwise be required. Its advantages over the latter operation are doubtful in inveterate cases, since in these the bones are altered in shape, and this deformity will not be overcome by any division of soft parts alone. To suppose that an extreme case of club-foot in a patient past puberty—one in which the weight is borne on the outer surface of the os calcis alone, and in which all the tarsal bones are malformed—will be cured by Phelps's operation alone implies too vivid an imagination.

Operation for Confirmed Flat-foot.—The treatment of extreme flat-foot by the excision of a wedge of bone was introduced by Mr. Golding Bird in 1878. (*See* paper in *Lancet*, April 6th, 1889.) The wedge was taken from the inner side of the foot, and was composed either of the scaphoid alone, or of the scaphoid together with the head of the astragalus. Dr. Ogston (*Trans. Med. Soc.*, 1884) excised the astragalo-scaphoid joint in such a way that the parts removed were wedge-shaped. He then fixed the astragalus and scaphoid together with pegs.

The actual operation needs no detailed description. The bone is exposed by a simple incision, and the parts to be removed are bared with a rugine. The wedge is cut out with a chisel and mallet. No tourniquet is required. The foot is adjusted upon a suitable splint after the operation, and is treated as a compound fracture.

One obvious objection to the operation is that the patient must not bear weight on the foot for some three months or so—before the union is quite firm. Another is that the operation deals with only one small joint in the foot, while the sinking downwards in severe valgus concerns all those in the various transverse and longitudinal arches. For these reasons the operation can be indicated but very rarely, and its value is still very doubtful. Excision of the astragalus (*see* page 756) has been performed in this condition, as also for extreme varus, and the results are said to have been good. We have never met with a case of flat-foot in which any form of osteotomy appeared to suggest itself as a useful measure.

CHAPTER II

OPERATIVE TREATMENT OF UNUNITED FRACTURE

WITHOUT entering into the general question of the indications for interference in cases of ununited fracture, it is necessary to point out that *delayed* union of broken bones is not uncommon; that so-called non-union depends upon many conditions, some constitutional, some local; and that often in cases which have apparently become hopeless much can be done by general treatment and by simple local measures which are short of operation.

On the other hand some cases of non-union will resist the most persevering efforts of the surgeon, every form of operation (with or without mechanical fixation of the fragments together) only resulting in failure. Thus out of 70 cases of ununited fracture in young children collected by Mr. D'Arcy Power no less than 50 were given up as hopeless, i.e. the limb was amputated or the fibrous union lasted into adult life.

1. UNUNITED FRACTURE OF LONG BONES

In dealing with ununited fractures of such bones as the femur, the humerus, the tibia, and the radius, the operation to be first described consists only in resecting the ends of the broken bone, and then retaining them in accurate apposition by means of splints. Of the different measures of which I (F. T.) have myself made use, none has given such satisfactory results as has this simple procedure.

Certain of the modes of treatment advised have little to recommend them. Among such must be named the passing of a large tenotome between the fragments, the introduction of a seton, the insertion of gilt steel needles into the bone, or the driving in of a number of ivory pegs.

These timid and half-hearted measures were possibly justified in the days which preceded the introduction of antiseptic methods in the treatment of wounds. They are feeble measures, which are

blindly administered, and which trust more to good fortune than to sound science.

At the present day—when the making of a large wound is (within reasonable limits) not much more serious than the making of a small one—these imperfect operations have no reason for their existence.

After the resection operation the ends of the broken bone, freshened and freed of all intervening tissue, are brought into actual and close contact, and may be said to be placed in the best condition for uniting. The question of wiring the fragments will be considered in a separate section. Before the operation is undertaken in any case, the exact position and relations of the bone-ends should be demonstrated by means of the X-rays.

Operation by Resecting the Ends of the Bone.—Before undertaking this operation, the surgeon should understand that its success depends more upon the completeness of the arrangements that are made for keeping the bones in position after the operation than upon the operation itself, provided the latter be carried out with due care. The operation involves the making of a compound fracture, the limb is at the time flail-like and distorted, the muscles are shortened, the fragments are very possibly displaced.

In these circumstances it is necessary that the most efficient form of splint should have been prepared, and that all arrangements should have been made for fixing the limb and maintaining such extension as may be necessary.

Care in the adjusting of the fragments and in the after-treatment are the main elements of success in the present class of case.

The principal features of the operation are the following :—

(1) The strictest antiseptic measures must be observed. It is essential that the wound should heal by first intention.

(2) The incision must be free. In many instances the wound must be very extensive. A small incision may greatly complicate the operation, may prevent the full exposure of the bones, and may lead to undue contusion and laceration of the soft parts. The surgeon is likely to err in the direction of making the wound too small rather than too large.

(3) The wound should be in the long axis of the limb as a rule, and should be so placed as to reach the bone by the shortest

route and with the least damage to the soft parts—the nerves and the blood-vessels of the region.

(4) The bones must be well exposed and cleared of the fibrous and cicatricial tissue which will probably surround them. This tissue need not be removed, but the bones must be well freed of it.

(5) Each bone-end should be bared of its periosteum, which is turned back by means of the rugine with as little disturbance of its connections with the surrounding soft parts as is possible. It is only necessary that the actual free end of the bone be so laid bare.

(6) With a fine and sharp chisel the operator should then proceed to remove a thin lamella from the end of the bone, so that the fresh cancellous tissue is exposed over the entire section of the shaft. No more need be removed than is necessary to expose a surface of living vascular and active bone. Both fragments are to be treated in the same way. The manner in which the bone is cut is of great importance. The chisel should be so employed that the two raw surfaces can lie in contact, and can, if possible, overlap.

While there is applied to the limb the fullest amount of extension that an assistant can exercise, the surgeon should ascertain what position the fragments will occupy when the limb is finally adjusted upon the splints he has prepared; and he should, if necessary, re-apply the chisel until the two fragments fit one another and are made to lie easily in contact when the deformity has been corrected.

Mere sawing off of the ends of the bones is not sufficient, nor is the mere baring of the broken extremities all that is required. The bones must be fashioned, and be so moulded with the chisel that they may be brought into proper contact.

During the use of the chisel every care must be taken by means of spatulæ and retractors, held by watchful assistants, to protect the soft parts. It is convenient to steady the limb against a wooden block covered with a sterilised towel during the time the chisel is being used.

(7) The wound cavity should then be well flushed out with warm sterile water, directed into its depths by a suitable irrigator. Sutures are applied, but the close approximation of the margin of the skin-wound is not desirable. The use of a drainage-tube

is rarely required. The use of the elastic tourniquet is to be avoided whenever possible.

The limb must finally be well and carefully secured upon a splint, and fixed in the best possible position. It may be necessary to divide tendons, or sever rigid bands of cicatricial tissue.

In neglected fractures of the thigh, in which non-union has followed, the patient should be kept in bed for a week or so before the operation, and have extension applied all that time.

This preliminary measure allows the swelling which often surrounds the seat of fracture to subside, and enables the

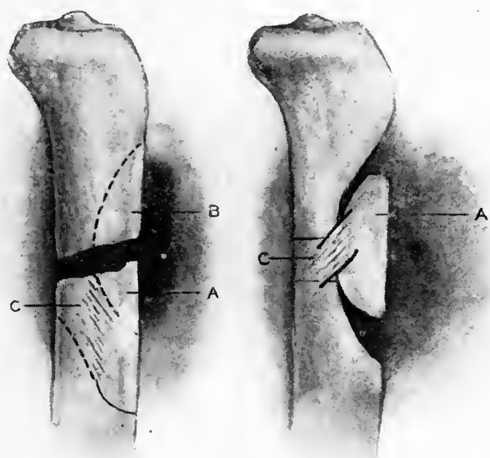

FIG. 443.—SIDE VIEW OF TIBIA, TO ILLUSTRATE BONE-GRAFTING.
The portion of bone, B, from the upper end is wholly removed; the bone-graft, A, is cut from the lower fragment; C, connecting band of periosteum.

surgeon to make trial of the splint he proposes to employ after the operation.

The *after-treatment* of these cases differs in no way from that of compound fracture.

Bone-grafting for Ununited Fracture.—In addition to freshening the two ends of the bone in the manner just described, a bone-graft may sometimes be employed with advantage. The most simple and efficient method of grafting is the autoplastic, which is best illustrated in the case of a subcutaneous bone such as the tibia (*see* Fig. 443).

A tongue-shaped flap of skin is cut, the base of which (two inches or more in width) corresponds to the distal end of the upper fragment. The flap is about three inches in length, its apex being downwards, well over the lower fragment. At this lower end, after division of the periosteum, a thin layer of bone and periosteum is detached by means of a chisel. The whole flap of skin, periosteum, and bone is thus detached upwards until the site of fracture is reached. Any soft tissues which intervene between the fragments are then cleared, and the latter freshened with the chisel. A shallow groove on the front of the upper fragment may be made for the reception of part of the bone-graft, which is laid down over the gap, the skin being fixed by sutures. The lower sides of the wound can usually be brought together after undermining them. It appears to be unnecessary to use any special method for fixing the bone-flap in position, the skin-sutures and dressings being sufficient for the purpose.

A series of successful cases is described and figured by Zelinsky in the *Beiträge zur klin. Chirurgie*, Bd. lxxxiv., 1906. The paper gives convincing proof of the value of the method by means of radiographs from many cases. We advise that in non-union of deeper bones than the tibia a careful trial should be made of bone-grafting—after the method illustrated in Fig. 443. The graft might still retain its connection with one end by a broad strip of periosteum, and in some cases might be secured in place by kangaroo tendon tied round the bone above and below. My experience (J. H.) in grafting bone has been that to fix the graft with screws or nails is almost impossible without rough handling of it and endangering its vitality. After the graft has been secured in place and the wound carefully sewn up without drainage (it is usually best to sew up layer by layer), the limb operated should be secured on a splint or in plaster of Paris so as to give it absolute rest for one month at least. If bone-grafting be adopted we advise that the bone should be taken from the patient himself, and not from "a recently amputated limb," or from the lower animals. Some writers assert that grafts from the femoral shaft of young dogs or rabbits are specially effective. We have employed both with every possible care, and can testify that:

(1) The animal graft, if perfect asepsis be obtained, does remain *in situ* as desired for a certain length of time.

(2) At the end of a few weeks it is either cast off as a foreign body or it is gradually absorbed.

(3) In no single case have we seen evidence that the animal graft became incorporated with the bone of the patient or had any appreciable effect in stimulating the formation of new bone.

To make use of a bone-graft from the same patient, and from the bone that is fractured, and to retain in part its vascular connections, is a much more hopeful procedure. It is exactly on a par with autoplastic flap operations on the soft tissues, which almost always succeed, whilst grafting from a distance frequently fails.

Fixation of the Bone-ends by Wire, Screws, Nails, and other Apparatus.—Although these methods have been advocated by some surgeons (especially by Mr. Arbuthnot Lane) not only in cases of non-union but in many of recent simple fracture, they are open to considerable objection. The metal is likely to act as a foreign body, to become loose, and to require subsequent removal, even if suppuration and necrosis do not occur. In the vast majority of simple fractures such operations are both unnecessary and attended with needless risk.

When the surgeon has to deal with a case of non-union of a bone which is deeply placed, such as the humerus, and when the method of refreshing the ends, or autoplastic bone-grafting, with retention in good position, has already failed, a trial may be given to mechanical fixation by the use of wire or screws, etc.

The ends of the bone must be thoroughly isolated from the soft tissues (leaving the periosteum intact), and should be so bevelled as to fit well together as they overlap. Two holes should be bored through the opposed surfaces. Whether silver wire or fine steel nails or screws are employed must be left to the discretion of the operator. Wire is, perhaps, the most difficult and tiresome to introduce; on the other hand, if screws or nails are employed great care should be taken lest the sharp ends project beyond the bone in dangerous proximity to important vessels or nerves. The sharp end of the nail screw, if it projects on the far side of the bone, should be cut off with strong pliers.

Bone or ivory pegs are in our opinion quite useless; they generally break, and they rarely fit the apertures made for them.

Messrs. Collin, the well-known instrument-makers of Paris, have lately introduced some sharp lance-pointed screws, which

are plated so as not to rust, are made of all sizes, and are the most convenient to use of all the apparatus of the kind that we have seen. It should be noted, however, that both screws and nails when fixed in human bones are apt to become loosened, and to need removal after some weeks or months have elapsed.

Silver wire will generally remain in for an indefinite period.

There are a great number of metal plates, steel staples or clamps which have been devised for fixing on to the bone at the site of fracture. It does not seem worth while to describe them in detail, and it should be remembered that in cases of non-union of fractures of the long bones the mere approximation of the ends —however close—frequently fails in obtaining the result desired.

2. Ununited Fracture of Short Bones

OPERATIONS FOR FRACTURED PATELLA

It need hardly be observed that the surgeon will only operate in cases of transverse fracture in which the lateral aponeurosis has been torn so as to allow the fragments to gape asunder, and in which there is no contra-indication to the operation. For example, chronic alcoholism, extreme obesity, any marked visceral disease, or old age should be an absolute bar. Apart from the question of the general condition of the patient there are certain points about the fracture itself which may lead the surgeon to decline operation. Such are comminution of the patella (which is, however, rare) or the very small size of one fragment compared with the other. As already noted, if the fracture does not "gape" appreciably, wiring should not be done. The time at which the operation is performed is important, since the most thorough disinfection of the skin must be carried out for some days before; moreover, it is better not to operate until the effusion has largely subsided. The most favourable time for operation is from four to ten days after the injury, the leg having been kept immobile on a long back-splint, with foot-piece, and the field of operation having been prepared by daily use of alcoholic solution of carbolic acid, etc., for at least four days, with the continuous application of antiseptic compresses. In short, the nurse should prepare the patient as for operation

on four successive days. During the operation itself the most strenuous precautions as to asepsis should be observed.

The Wiring of the Fragments.—This operation was introduced by Lord Lister in 1883, and is carried out, it is needless to say, under the most careful antiseptic precautions.

Both operator and assistants should wear sterilised rubber gloves.

It is most convenient for the patient's limb to be slightly raised, the knee being flexed a few degrees over a sand-bag. The field of operation should be carefully isolated by moist sterilised towel secured closely round the limb by Wells' forceps.

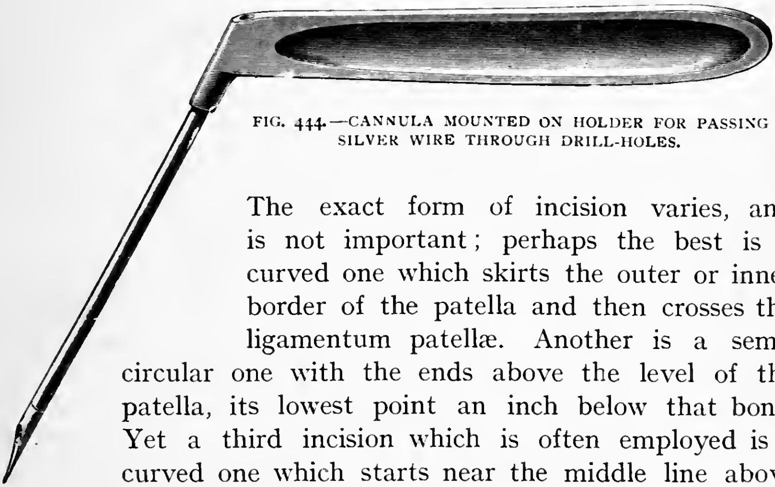

FIG. 444.—CANNULA MOUNTED ON HOLDER FOR PASSING SILVER WIRE THROUGH DRILL-HOLES.

The exact form of incision varies, and is not important; perhaps the best is a curved one which skirts the outer or inner border of the patella and then crosses the ligamentum patellæ. Another is a semicircular one with the ends above the level of the patella, its lowest point an inch below that bone. Yet a third incision which is often employed is a curved one which starts near the middle line above the patella, sweeps round one border, and ends near the middle line below. In either case the cut is made down to the aponeurosis, and the superficial fascia and fat are reflected upwards with the skin, so as to expose at once the gap between the fragments.

It will be seen that the wound does not lie directly over the fracture; this is a useful precaution. The flap is retracted and held out of the way by a single suture-retractor.

The torn fibrous aponeurosis or periosteum of the patella will be found to dip down into the space between the fragments, and should be trimmed off cleanly with scissors or scalpel level with the line of fracture. All blood-clot should be cleared

from the joint by gentle sponging. The fragments are now secured by silver wire in the following manner: Corresponding points on the two fragments are carefully selected, and the investing aponeurosis over each is incised longitudinally down to the bone in two places, since two wires will secure better apposition than one. A drill is now passed obliquely downwards so as to emerge close to the cartilaginous surface, and a special cannula (*see* Fig. 444) is introduced through the drill-holes. The further from the fractured surface of each fragment, i.e. the closer to the border of the patella, the drill is introduced, the better will be the hold of the wire and the less the risk of its pulling through the bone as it is tightened up. For making the holes the electric motor is sometimes used with

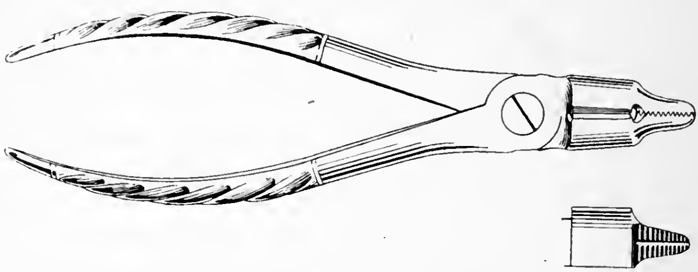

FIG. 445.—PLIERS FOR TWISTING AND CUTTING THE SILVER WIRE.

the drill. It acts rapidly, but is apt to slip, and to twist up shreds of aponeurosis. We have tried all kinds of drill, and on the whole prefer a hand drill of the simplest form. By means of the cannula it is then easy to pass the silver wire. This should be about one-sixteenth of an inch thick. Both wires are now drawn tight, and twisted with pliers (Fig. 445) so as to bring the two fragments into perfect apposition; the twisted ends are cut short and hammered down (Fig. 446) into the grooves already made in the periosteum. Drainage of the knee-joint is not required, and introduces an element of risk. The skin-wound is sewn up, and the limb placed in a comfortable position (i.e. not too fully extended) on a back-splint. As soon as the wound has soundly healed, in from two to three weeks, the patient is encouraged to bend the knee. The wire should be left in, as it is an important element of strength, preventing re-fracture.

Massage and gentle passive motion should be employed at the end of a fortnight. Some surgeons use only one wire, but with this it is more difficult to secure good apposition.

Modifications of the Operation, etc.—Some surgeons object to the use of silver wire on the ground that it will have to be removed later. The answer to this is that it should never be necessary to remove the wire. We have followed up many cases years after wiring, and in no single instance had the wire caused any trouble.

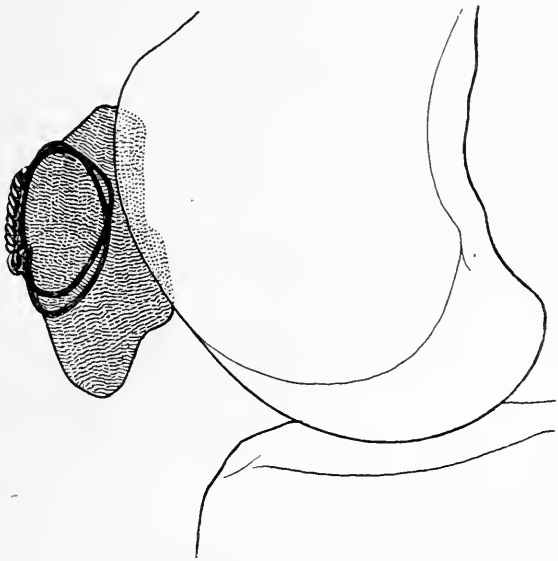

FIG. 446.—FROM RADIOGRAPH OF WIRED FRACTURE OF PATELLA, TAKEN THREE YEARS AFTER THE OPERATION.

The two silver wire loops are shown ; perfect bony union has occurred. Note the twisted ends of the wires hammered down.

In fact, if the ends have been properly buried in the periosteum it becomes impossible in most cases to detect the wire by palpation later. We are strongly in favour of using two wires, and both of good thickness, for these reasons :—

(1) We have known a single wire to cut through, and the fracture to re-open three months after the operation (Fig. 447).

(2) We have had to operate a second time for a fracture which we had wired two months before, with two wires of slightly lesser calibre than we usually employed. The

patient in stepping from a tramcar broke both wires, and re-opened the fracture.

(3) The patella forms new bone, it mends a break, with more difficulty and slowness than almost any bone in the body. Hence for some months the wire alone will be the element of strength at the line of fracture.

(4) The use of catgut, and to a lesser extent of kangaroo tendon, as the uniting medium is open to objections. The catgut, however stout, will be absorbed in a few weeks (we have known it disappear and the fracture re-open within ten days of its insertion), the tendon may become loosened or rupture on a strain that stout wire would have resisted. The tendon is, however, remarkably strong, and the chief objection to its use is that it is difficult to get such perfect apposition of the fragments when tying it as one can on steadily tightening up the wire by torsion.

The Operation in Cases of Old Fracture of the Patella.—Contrary to what was taught for long, these cases of wide separation with wasted quadriceps are the worst from the operator's point of view, and the results are sometimes most unsatisfactory. The edges of the bone are found to be flattened or altered so that it is difficult to make two good surfaces to approximate, and, moreover, it is quite impossible to bring them together without dividing the quadriceps muscle above the patella. Such a division is probably fatal to the muscle ever regaining power. Lord Lister saw this from experience, and advocated two modifications of the operation which may make it again worthy of trial in cases of long-standing fracture (*see* paper by Lord Lister,

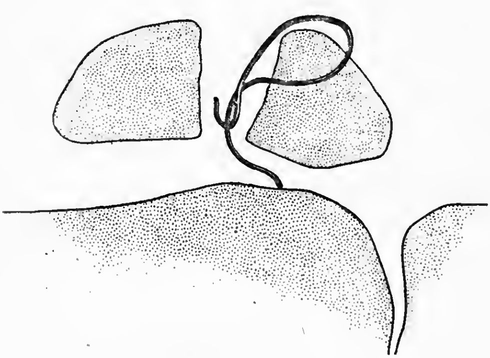

FIG. 447.—RADIOGRAPH FROM A CASE IN WHICH A SINGLE SILVER WIRE HAS BEEN USED TO FIX THE PATELLA.

Three months later the fracture gave way again, and the wire is seen to be loose. It was removed and the bone re-wired with two loops, with success.

Brit. Med. Journ., April 11th, 1908). These modifications are the following: 1. The wire is passed as single mattress suture, as in intestinal work, so as to take a broad hold of the fragments. Lord Lister holds that it will be less likely to cut through the bone than if two separate wires are used. 2. No attempt is made at the time of the first operation to force the fragments together. They are approximated as far as is possible without undue tension on the wire—which remains as a bridge between them. At the end of a month or more a second

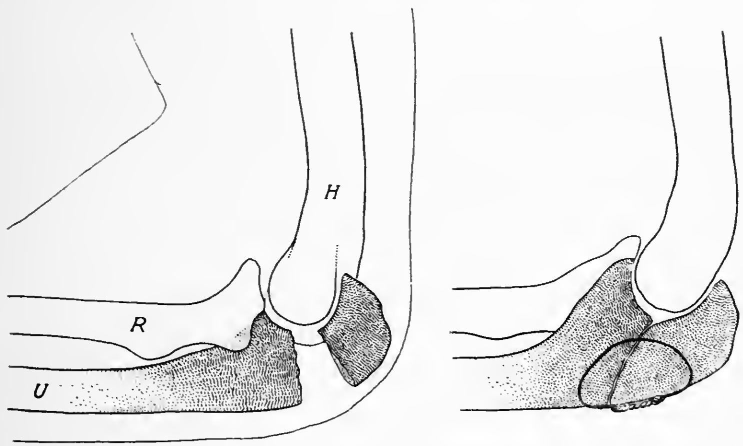

FIG. 448.—RADIOGRAPH OF FRACTURE OF OLECRANON, BEFORE AND AFTER WIRING. The wire should pass near to the articular surface in order to obtain a good result, and should be twisted and hammered down close to the bone.

operation is performed, and the fragments are brought close together with fresh wire.

Even with these modifications we believe that some division of the quadriceps will be found necessary, and that bony union is hardly likely to be obtained. Lord Lister tried the above procedure on two or three patients only.

THE OLECRANON

The operations performed upon this bone are carried out on the same lines as those indicated in dealing with fracture of the patella. They should be reserved for recent cases of fracture in which there is well-marked separation between the

fragments. Otherwise a good result will be obtained by simple treatment on a splint in the extended position of the elbow.

The procedure of the operation differs in no way from that of wiring the patella, save that one wire instead of two should be used (Fig. 448).

Care should be taken in drilling the bone to pass the drill as near to the articular surface of both fragments as possible, and to bury the twisted ends well. The wire should rarely if ever need to be removed subsequently. It is well to keep the arm on an anterior splint until the wound has soundly healed; within ten days passive motion of the elbow-joint should be begun.

Arthrotomy

TREATMENT OF LOOSE CARTILAGES

An operation of this kind may be performed with either of two objects—first, to remove one of the semilunar cartilages which has been torn from its attachments and perhaps wrenched in two; and secondly, to extract a loose body formed of cartilage or bone, but which has no connection with the semilunar cartilages. The site of the incision differs in the two cases.

1. When the operation is required for what is known as **Hey's internal derangement of the knee joint**—i.e. a detached semilunar cartilage—experience has shown that it is better to excise as much of the cartilage as possible, rather than to attempt to fix it again in position by sutures. The latter proceeding is difficult and uncertain, and the loss of a semilunar cartilage makes no difference in the usefulness of the joint. This is well brought out in a paper by Mayo Robson (*Brit. Med. Journ.*, April 12th, 1902), in which twenty-five cases are narrated.

In the great majority of cases the incision will be required on the inner side of the joint, and an oblique or slightly curved one should be made from the lower edge of the patella downwards and backwards directly over the semilunar cartilage concerned. While this incision is made the knee should be kept semi-flexed. The position of the lateral ligament, whether external or internal, should be noted, and care taken not to injure it in the deep part of the incision which opens the joint.

The cartilage will in some cases be found to have been torn, and if so, both loose ends should be grasped with toothed forceps and dissected out with scissors or a tenotomy-knife. The best rule is to remove as much of the cartilage as can be reached through the wound. It is rarely possible to remove the posterior end of either cartilage, but this does not matter, as there is no risk of this part becoming nipped between the two bones. It is more important not to injure the lateral ligament than to extract the whole cartilage. The less the joint is moved during the operation the better. Catgut or fine kangaroo-tendon sutures are used to sew up the synovial membrane and capsule of the joint; no drainage-tube should be used, the skin-wound being sewn up with silkworm gut.

The limb should be kept at rest on a splint for ten days, and if a few degrees of flexion are provided for by a pad behind the knee, the comfort of the patient is decidedly increased. On first getting about, the patient should support the joint with an elastic bandage. The patient will not be allowed to walk for about a fortnight.

Sir A. Fripp (*Polyclinic*, Dec., 1904) recommends some slight modifications of the method described above. He rightly urges that neither the surgeon's nor the assistant's fingers should enter the wound, only sterilised instruments being allowed to do so, and also that the lateral ligament should on no account be divided. He inserts a drainage-tube into the synovial pouch, the tube being removed within forty-eight hours; he applies a very firm dressing and tight bandage, on which two ice-bags rest. No splint is employed, and passive motion is begun from the time of the removal of the drainage-tube. He uses no buried ligatures or sutures. A Martin's bandage is worn for six weeks.

It may be urged with reason that drainage can only be required if there is troublesome oozing at the time of operation; and the value of the ice-bags over the dressings is more than doubtful. Early passive motion is certainly desirable, and whether a splint is used or not for the first few days makes little difference.

In some cases the surgeon finds, on opening the knee-joint, that the internal semilunar cartilage, which was supposed to be loose, is perfectly normal. The joint should then be fully flexed

and rotated outwards, search being made with the aid of a strong light for some other loose body. As Mr. A. E. Barker has pointed out (*Brit. Med. Journ.*, Dec. 9th, 1905), an enlarged and indurated synovial fringe may be discovered, or even a loose external semilunar cartilage, which can be removed through the same incision on the inner side of the joint.

2. **The Removal of Loose Bodies.**—These are usually developed as the result of injury, though osteo-arthritis may lead to their formation. As disaster has many times followed operation for their extraction, whether from the knee or other joints, the following rules should be followed :—

The operation should never be done whilst the joint is inflamed, but only when the synovitis has practically subsided—i.e. when the joint has lost any abnormal heat.

Rest of the limb on a splint for a day or two before the operation should be insisted on.

It is rarely worth operating for loose bodies when the signs of osteo-arthritis are unmistakable in that or other joints.

Finally, the strictest aseptic precautions must be observed, as in operating for detached semilunar cartilage.

To emphasise the risk which may attend operations of this kind, we may mention two cases. In one, a man aged forty, an arthrotomy of the knee-joint was performed for a loose body whilst the joint was still in a condition of subacute synovitis. Intense inflammation followed, and the patient died within a few days of the operation.

In another case, a young woman with a loose body in one elbow-joint, arthrotomy for its extraction resulted in cellulitis of the arm, requiring deep incisions. In making one of the latter the musculo-spiral nerve must have been divided, and the final result was a condition of drop-wrist complicating bony ankylosis of the elbow-joint in a faulty position.

Until of late years, two measures were advised in the extraction of loose cartilages, with the object of rendering it safer and easier.

These were the preliminary harpooning or fixing with a needle, and subsequent cutting down on the loose body ; and, secondly, its extraction in two stages—i.e. forcing it into a subcutaneous cavity made by incision of the capsule, and then some days later completing the extraction. With regard to the second plan,

it is unnecessary to say more than that its drawbacks and the absence of gain in safety are obvious.

But as the plan of harpooning the loose body is still resorted to, the following points should be noted with regard to it :—

It is usually unnecessary in view of the value of skiagraphy in determining the position and number of intra-articular bodies, and it is certainly dangerous. The needle used on the spur of the moment may not be aseptic, and it is likely to slip off the side of the loose body, thus inflicting a punctured wound of the joint for no purpose.

A joint should never be opened merely to explore for a suspected loose body ; the latter should have been plainly felt by the surgeon or seen with the aid of skiagraphy. If the patient can work it up into the synovial pouch above the patella before the operation, so much the better, but as these loose bodies are rarely pedunculated or attached, movements of extension and flexion, etc., under the anæsthetic usually secure this result.

The incision should be made directly over the loose body, on whichever side of the patella it happens to be. Division of the thick fibres of the quadriceps is best avoided, as it causes hæmorrhage, and the position of the superior articular arteries should be borne in mind. The surgeon or his assistant has been pressing the loose body towards the incision, and with the escape of synovial fluid it is often expelled. If not, the surgeon's finger explores the pouch, and the extraction is effected with a volsellum forceps. Occasionally a fibrous pedicle will have to be cut through with scissors. Loose bodies are often multiple, and in a case operated on by one of us (J. H.) over 300 were extracted from the knee-joint of a young adult at the same sitting. In this case the only method suitable was to wash them out from the joint with a stream of sterilised water. Strangely enough, the formation of the loose bodies has since ceased. Separate layers of sutures should be employed for the synovial membrane, the aponeurosis, and the skin.

The after-treatment has already been described.

CHAPTER III

GENERAL CONSIDERATIONS ON EXCISIONS OF JOINTS AND BONES

By the term "excision of a joint" is implied the removal of the articular extremities of the bones entering into the formation of the joint, together, necessarily, with the cartilage and synovial membrane, the procedure being carried out with the least possible amount of injury to the surrounding soft parts.

Formal excision of a joint may in certain cases be replaced by what is called "erasion," meaning thereby the complete removal of the diseased synovial membrane, with perhaps a partial removal of the joint ends of the bones, where diseased, by means of gouge or chisel.

The excision of a bone may apply either to the complete removal of a bone together with its articular extremity, e.g. the inferior maxilla; or to the removal of a portion of a bone, e.g. the diaphysis of the humerus, or the acromial end of the clavicle.

Instruments Employed.—The following is a list of the instruments that may be required in an excision operation:—

Scalpels. Bistouries (blunt and sharp-pointed).
Dissecting and artery forceps. Pressure forceps.
Scissors. Bone-forceps. Sequestrum forceps.
Probes; directors.
Excision knives.
Ivory or metal spatulæ. Retractors of various kinds.
Lion forceps.
Periosteal elevators. Rugines.
Saws of various kinds.
Chisels and mallet.
Bone-gouges. Sharp spoons.

Certain of these instruments require a special notice.

The Excision-knife.—This knife should have a large handle and a short but stout blade (Fig. 449). It is an instrument by means of

which the surgeon can give the short, strong, clean, and heavy cuts down to the bone which are so conspicuous a feature of excision operations. Fig. 449 shows the most useful form of knife for general purposes. Fig. 450 represents an excision-knife with a straight edge, which will be found very convenient in dealing with some irregular surfaces, and also in dividing the periosteum.

The Periosteal Elevator or *Rugine.*—Many patterns of this instrument exist. The rugine is employed to strip the periosteum from the bone (Fig. 454).

FIG. 449.—EXCISION-KNIFE.

FIG. 450.—EXCISION-KNIFE.

The most convenient instruments are those of Farabeuf. Fig. 451 shows the straight rugine, which will meet the requirements of most operations; and also the curved rugine, which is admirably adapted for curved and irregular surfaces. It has likewise been used as a conductor or director for the chain-saw.

The ordinary periosteal elevator (Fig. 452), as it is figured in the catalogues of English makers, is a useful instrument. It is of little service in actually detaching the periosteum, but is useful in raising it when it has been detached, and in guarding the soft tissues from accidental division by the chisel, etc.

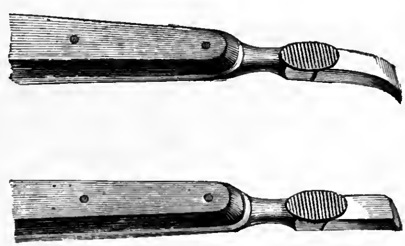

FIG. 451.—FARABEUF'S RUGINES, STRAIGHT AND CURVED.

Retractors.—Retractors play a very important part in excision operations. Those of the ordinary pattern will suffice. The most serviceable are of steel, and are either rectangular or slightly curved.

A useful retractor can be made with a long, thin, and narrow strip of pliable metal (e.g. malleable iron plated). Its application in a case of excision of the elbow is shown in Fig. 469.

Good ivory spatulæ are of service to protect the soft parts during sawing.

Lion Forceps.—Of the various forms of lion forceps or bone-

holding forceps, Farabeuf's is perhaps the best. By means of its double axis it is enabled to grasp firmly a bone of any size, and will hold a metacarpal bone as steadily as it will fix the head of the humerus (Fig. 453).

Saws.—The particular kind of saw employed must depend upon the taste and custom of the individual surgeon. The best for most excision operations is a simple straight narrow saw, with a movable back. In some instances, e.g. in certain excisions for ankylosis, a rat-tail or key-hole saw is needed. If it be considered needful to give a

FIG. 452.—LANGENBECK'S PERIOSTEAL ELEVATOR.

curved surface to the free end of the bone, this may best be done by means of a slender Butcher's saw. French surgeons are for the most part in favour of the chain-saw, but that instrument has never held a prominent position with English operators.

General Conditions of Excision Operations.—The remarks in this and the following chapters apply especially to excisions of joints, but they may be taken as referring also, with appropriate modification, to resections of bones.

The excision of a joint may be practised for the relief of any of the following conditions: Advanced joint-disease; disease of the articular ends of the bones; injury, such as gunshot wound, compound

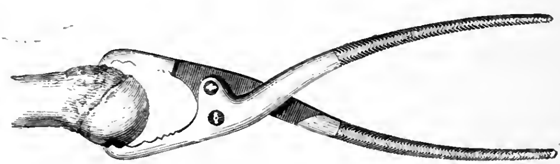

FIG. 453.—FARABEUF'S BONE-HOLDING FORCEPS.

or unreduced dislocation; ankylosis; and certain deformities. The great majority of the cases of excision have been carried out for the relief of tuberculous disease of the joint ("white swelling"), and the chief discussions relative to excision, and the main statistics that deal with the operation, are concerned with excisions for chronic joint-disease.

In performing excision of a joint, the following general points are to be observed:—

1. The whole of the diseased tissue must be removed.

2. The amount of the bone removed must be limited by such common surgical requirements as are necessary to ensure the prospect of a useful—or, at least, not utterly useless—limb. It is possible to remove so much bone that although the wound heals firmly and well, the patient is left with a flail-like limb, which is an actual encumbrance.

3. The soft parts must be as little disturbed as possible. When practicable, the connections of tendons and ligaments must be preserved, and care must be taken to avoid injury to vessels and nerves of any magnitude.

4. It is important in young subjects that the active epiphysis be

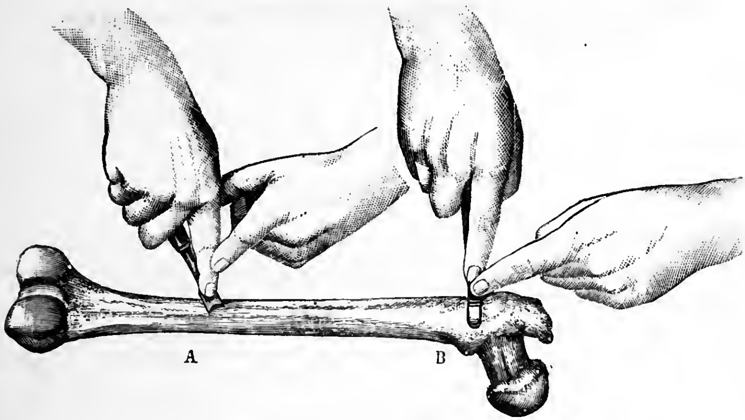

FIG. 454.—METHOD OF USING THE RUGINE.
A, Over a level, and B, over an unequal surface. (*Ollier.*)

not destroyed, lest a greatly shortened limb result—a matter of infinite consequence in the lower extremity.

5. The bones must be so divided as to be adapted to the purposes of the new articulation, or be favourable for ankylosis in a good position. In excising the knee-joint, it is possible that one careless operator may bring about a condition of knock-knee in the healed limb, and another a condition of bowed leg.

6. The after-treatment must be a matter of patience and care, and the selection of a suitable apparatus for the fixing of the limb is a subject of considerable moment. In the upper extremity, and in the hip and ankle, a joint capable of some degree of movement is expected after the excision ; in the knee ankylosis is generally sought for.

7. The surgeon must be fully alive to the general surgical aspects of the case, to the condition of the patient, to his prospects of standing

a long and severe operation, and to his capacity for exhibiting fair powers of repair. It is not uncommon for second operations of a minor character to be required after excision of a joint that was extensively diseased. Thus we have known a good final result to be obtained after excision of the knee-joint by repeated scraping of sinuses.

As excision is in most cases performed for tuberculous disease, it is essential to remove every fragment of infected tissue—often a tedious matter, and almost impossible if free oozing of blood is occurring. Hence the use of Esmarch's tourniquet is often essential.

The skin-incisions must be considered with great care. The more modern operations favour the most simple form of wound—a single straight cut. The measures adopted by some of the earlier operators were very complex and needlessly extensive.

It must be confessed that of late years the excision of joints has become less common. This is due to the fact that the treatment of tuberculous affections of joints has been greatly advanced in recent times, and it is a matter more or less of discredit to find a joint which has advanced to a state of dissolution calling for excision. In private practice especially excision of a joint has become a most rare operation. A large proportion of cases which would at one time have been treated by excision are now dealt with by erasion of the joint. Excision of a joint will never again occupy the very prominent and important position which it held in surgery about the middle of the last century.

Note on the Sub-periosteal Method of Excision.—The elaborate methods for preserving the periosteum with the capsule of the joint that were devised by the late Prof. Ollier are not likely to be followed by any surgeon performing excision. Too much care in this direction will probably defeat its object in a case of tubercular disease by retaining foci of disease.

Of course, whenever the periosteum is found to be quite healthy it should be retained, and in performing erasion it is sometimes possible to preserve the outer fibrous capsule of the joint to some extent, but the great point is to remove all diseased tissue thoroughly. This is the only safe rule to follow. At the same time every precaution should be taken to preserve the attachment of all important muscles or tendons around the joint excised.

CHAPTER IV

EXCISION OF THE WRIST AND OF THE ELBOW

I. EXCISION OF THE WRIST

THIS operation, when complete, consists in the removal of the whole of the carpus, the lower ends of the radius and ulna, and the articular extremities of the metacarpus.

The operation is practically limited in its application to cases of tubercular disease in adults, and is therefore but rarely performed. Nevertheless it sometimes gives an excellent result, the shortened hand being far superior to an artificial one. In young children complete excision of the wrist can hardly ever be required. Tubercular disease of the carpal bones in them is best treated by scraping away the diseased part, not by a complete excision.

Anatomical Points.—The wrist-joint is separated from the lower radio-ulnar joint by the triangular cartilage which is attached by its apex to the styloid process of the ulna and by its base to the inner margin of the articular surface of the radius, where it blends with the articular cartilage.

The joint is protected by strong tendons. On the inner side are the extensor and flexor carpi ulnaris ; on the outer side the extensor ossis metacarpi pollicis, the extensores primi and secundi internodii pollicis, and the two radial extensors of the carpus ; in front are the deep and superficial flexors of the fingers, the flexor longus pollicis, palmaris longus, and flexor carpi radialis. Posteriorly are the tendons of the extensor indicis, extensor communis, and extensor minimi digiti.

These tendons, on passing the wrist, are—with the exception of the palmaris longus and flexor carpi ulnaris—enveloped by the synovial sheaths, the positions of which are shown in Fig. 455.

The bones are united by means of a capsular ligament, of which the anterior part (the so-called anterior ligament) is the strongest portion. The posterior part is quite thin. More substantial fibres

exist upon the lateral parts of the capsule—the so-called external and internal lateral ligaments.

A more or less complete layer of ligamentous tissue covers the anterior and posterior surfaces of the carpus, and to thickened portions of it various names are given. Ollier would have the carpus regarded surgically as one short wide bone, capped with cartilage at either end, and covered with ligamentous tissue of unequal thickness.

In the wrist and the carpus are seven separate synovial sacs, the disposition of six of which is shown in Fig. 456. The seventh sac is a minute one between the pisiform and cuneiform bones.

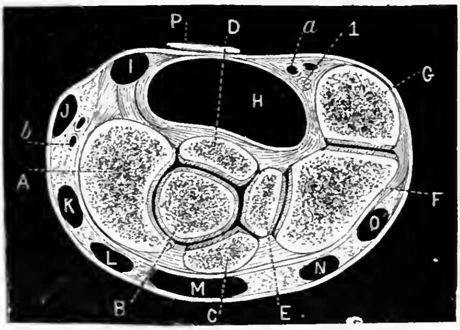

FIG. 455.—SECTION THROUGH THE WRIST. (*After Henle.*)

A, Scaphoid; B, Os magnum; C, Semilunar; D, Semilunar; E, Unciform; F, Cuneiform; G, Pisiform; H, Compartment for flexor tendons; I, Flexor carpi radialis; J, Extensor ossis, metacarpi pollicis and extensor primi; K, Extensores carpi radialis longiore and brevior; L, Extensor secundi internodii pollicis; M, Extensores communis and indicis; N, Extensor minimi digiti; O, Extensor carpi ulnaris; P, Palmaris longus; *a*, Ulnar vessels; *b*, Radial vessels; I, Ulnar nerve.

It will be observed that the sac between the trapezium and the first metacarpal bone is quite distinct.

Figs. 457 and 458 show the position and extent of the lower epiphyses of the radius and ulna. They join with the shafts of their respective bones about the twentieth year. The lower extremity of the diaphysis of the ulna just reaches to the radio-ulnar joint; the lower end of the diaphysis of the radius is intrasynovial.

The carpus is entirely cartilaginous at birth, and the bones commence to ossify between the first year (os magnum) and the twelfth year (pisiform) after birth. The trapezium is an important bone from an operative point of view. It supports the thumb, is in very close relation with the radial artery, forms a groove for the flexor carpi radialis, and gives attachment to the opponens pollicis, the abductor pollicis, and the flexor brevis pollicis.

The tendons at the back of the wrist can be well made out in the healthy hand. The most conspicuous belongs to the extensor secundi internodii pollicis. It is rendered distinct when the thumb is extended and abducted. It leads up to a small but prominent bony elevation

on the back of the radius, which marks the cuter border of the osseous groove for its reception. This tendon, when it reaches the radius, points to the centre of the posterior surface of that bone, and indicates also roughly the position of the interval between the scaphoid and semilunar bones.

The lower end of the ulna is very distinct. When the hand is supine, its styloid process is exposed at the inner and posterior aspect of the wrist to the inner side of the extensor carpi ulnaris. In pronation, however, the process is rendered less distinct, while the head projects prominently on the posterior part of the wrist, and is found to lie between the tendons of the extensor carpi ulnaris and extensor minimi digiti.

The tip of the styloid process of the ulnar corresponds to the line of the wrist-joint, and a knife introduced below that joint would enter the articulation.

A knife entered horizontally just below the tip of the styloid process of the radius would hit the scaphoid bone.

A line drawn between the two styloid processes slopes downwards and outwards; its two extremities represent the extreme inferior limits of the radio-carpal joint, and it fairly corresponds to the chord of the arc formed by the line of that joint. The line between the styloid processes is slightly less than half an inch below the summit of the arch of the wrist-joint.

FIG. 456.—SYNOVIAL CAVITIES OF THE WRIST.

The radial artery winds round to the back of the wrist, just below the styloid process of the radius, lying upon the external lateral ligament of the joint, and beneath the extensors of the metacarpal bone and first phalanx of the thumb. It then runs over the scaphoid and trapezium, and, as it is about to dip between the two heads of the abductor indicis, is close to the carpo-metacarpal joint of the thumb.

The position of such branches of the radial and ulnar arteries as are distributed in the neighbourhood of the wrist must be borne in

mind. The vessels most apt to be wounded in excision of the wrist are the radial, the deep palmar arch, the anterior and posterior carpal arches, and the dorsal interosseous branch of the radial.

The Operation.—The main incision, which may be the only one, should be a longitudinal one placed just to the outer side of the common extensor tendons of the fingers, and over the metacarpal bone of the index. Whether it runs in a straight line (Boeckel and Langenbeck) or is slightly angular (Lord Lister) is not a matter of much importance. A second incision, placed on the ulnar aspect of the wrist, between

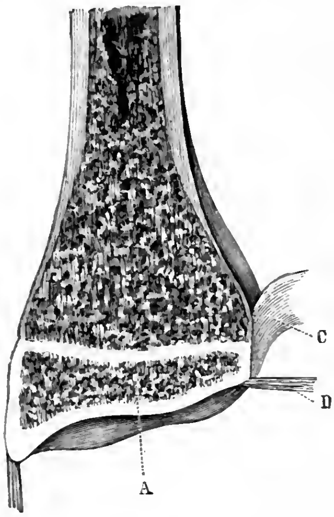

FIG. 457.—LOWER END OF THE RADIUS IN A SUBJECT AGED 16. (*After Ollier.*)

A, Epiphysis; B, Lateral ligament; C, Synovial membrane of radio-ulnar joint; D, Triangular ligament.

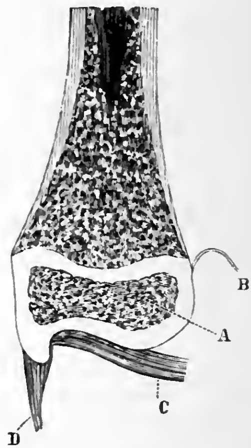

FIG. 458.—LOWER END OF THE ULNA IN A SUBJECT AGED 16. (*After Ollier.*)

A, Epiphysis; B, Synovial membrane; C, Triangular ligament; D, Lateral ligament.

the extensor and the flexor carpi ulnaris, may be sometimes required. The following description is based on Mr. Jacobson's account of Lord Lister's method. The radial incision is made as in Fig. 459:— "This incision is planned so as to avoid the radial artery, and also the tendons of the extensor secundi internodii and indicis. It commences above, at the middle of the dorsal aspect of the radius, on a level with the styloid process. Thence it is at first directed towards the inner side of the metacarpo-phalangeal joint of the thumb, running parallel in this course to the extensor secundi internodii; but on reaching the line of the radial border of the second metacarpal bone,

it is carried downwards longitudinally for half its length, the radial artery being thus avoided, as it lies a little farther out. These directions will be found to serve, however much the parts may be obscured by inflammatory thickening. The tendon of the extensor carpi radialis longior is next detached with the knife, guided by the thumb-nail, and raised, together with that of the extensor brevior, also cut; while the extensor secundi internodii, with the radial artery, is thrust somewhat outwards. The next step is the separation of the trapezium from the rest of the carpus by cutting forceps applied in a line with the longitudinal part of the incision, great care being taken of the radial artery. The removal of the trapezium is left till the rest of the carpus has been taken away, when it can be dissected out without much difficulty, whereas its intimate relations with the artery and neighbouring parts would cause much trouble at an earlier stage.

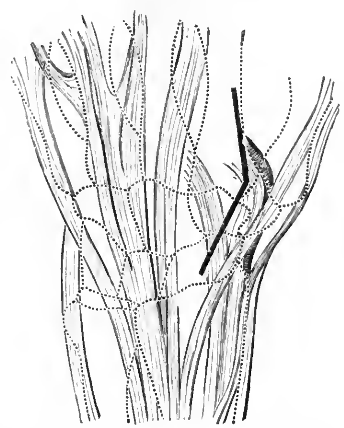

FIG. 459.—EXCISION OF THE WRIST. (LISTER'S INCISION.)

"The hand being bent back to relax the extensors, the ulnar incision should next be made very free, by entering the knife at least two inches above the end of the ulna immediately anterior to the bone, and carrying it down between the bone and flexor carpi ulnaris, and on in a straight line as far as the middle of the fifth metacarpal bone at its palmar aspect. The dorsal lip of the incision is then raised, and the tendon of the extensor carpi ulnaris cut at its insertion, and its tendon dissected up from its groove in the ulna, care being taken not to isolate it from the integuments, which would endanger its vitality. The finger extensors are then separated from the carpus, and the dorsal and internal lateral ligaments of the wrist joint divided, but the connections of the tendons with the radius are purposely left undisturbed.

"Attention is now directed to the palmar side of the incision. The anterior surface of the ulna is cleared by cutting towards the bone so as to avoid the artery and nerve, the articulation of the pisiform bone opened, if that has not been already done in making the incision, and the flexor tendons separated from the carpus, the hand being depressed to relax them. While this is being done, the knife is arrested by the unciform process, which is clipped through at its base with pliers.

"Care is taken to avoid carrying the knife farther down the hand than the bases of the metacarpal bones, for this, besides inflicting unnecessary injury, would involve risk of cutting the deep palmar arch. The anterior ligament of the wrist-joint is also divided, after which the junction between the carpus and metacarpus is severed with cutting pliers, and the carpus extracted from the ulnar incision with sequestrum forceps, and by touching with the knife any ligamentous connections.

"The hand being now forcibly everted, the articular ends of the radius and ulna will protrude at the ulnar incision. If they appear sound, or very superficially affected, the articular surfaces only are removed. The ulna is divided obliquely with a small saw, so as to take away the cartilage-covered rounded part over which the radius sweeps, while the base of the styloid process is retained. The ulna and radius are thus left of the same length, which greatly promotes the symmetry and steadiness of the hand, the angular interval between the bones being soon filled up with fresh ossific deposit. A thin slice is then sawn off the radius parallel with the articular surface. For this it is scarcely necessary to disturb the tendons in their grooves on the back, and thus the extensor secundi internodii may never appear at all.

"This may seem a refinement, but the freedom with which the thumb and fingers can be extended, even within a day or two of the operation, when this point is attended to, shows that it is important. The articular facet on the ulnar side of the bone is then clipped away with forceps applied longitudinally.

"If the bones prove to be deeply carious, the pliers or gouge must be used with the greatest freedom. The metacarpal bones are next dealt with on the same principle, each being closely investigated—the second and third being most readily reached from the radial, the fourth and fifth from the ulnar side. If they seem sound, the articular surfaces only are clipped off, the lateral facets being removed by longitudinal application of the pliers.

"The trapezium is next seized with forceps and dissected out, without cutting the tendon of the flexor carpi radialis, which is firmly bound down in the groove on the palmar aspect, the knife being also kept close to the bone to avoid the radial. The thumb being then pushed up by an assistant, the articular end of the metacarpal bone is removed. Though this articulates by a separate joint, it may be effected, and the symmetry of the hand is promoted by reducing it to the same level as the other metacarpals.

"Lastly, the articular surface of the pisiform is clipped off, the

rest being left, if sound, as it gives insertion to the flexor carpi ulnaris and attachment to the anterior annular ligament."

Comment.—It is almost unnecessary to say that the above description must be taken only as a guide, and that various modifications may be found advisable in the actual operation. Thus it has already been noted that a single dorsal incision will often suffice. Again it is very desirable to leave the trapezium if possible, whenever that bone is not diseased. The pisiform also may as a rule be retained. In some cases the metacarpal bones of the fingers only need erasion of their bases, and of course, if the trapezium can be preserved, its articulation with the metacarpal of the thumb should not be opened. To this last conservative measure we attach importance. If the extensors of the carpus must be divided they should be sutured down with kangaroo tendon as nearly as is possible to their former points of attachment.

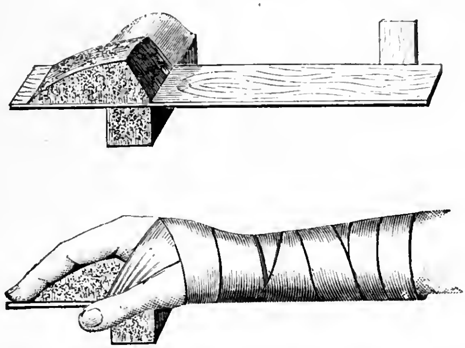

FIG. 460.—LISTER'S SPLINT FOR EXCISION OF THE WRIST.

After-Treatment.—The wound must be well drained, and be dressed with the most careful aseptic precautions.

The limb must be maintained upon a splint which will support the palm of the hand, will keep the wrist a little extended and the fingers a little flexed, while at the same time it will not prevent movements of the fingers from being carried out (Fig. 460).

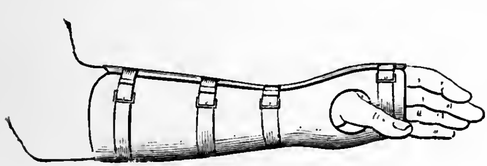

FIG. 461.—LEATHER SPLINT FOR THE WRIST.

A straight anterior splint, well padded, answers the purpose as well as the more complicated ones.

There is a constant tendency for the hand to assume the position of adduction, and this is apt to become more marked some time after the splint has been removed.

The limb will need to be maintained upon a splint for a considerable period, varying from two to six months.

I (J. H.) have obtained excellent results in several cases by the use of a single dorsal incision, the hand and forearm being fixed after the operation in a light plaster-of-Paris case, which leaves the fingers free, the plaster bandage being applied over a gauze and wool dressing. At the end of six weeks the plaster and stitches are removed, a second case being applied.

It is essential during the whole of this time that passive movements of the fingers be kept up. The fingers should be moved as early as the third day. The wrist should be kept at rest until the parts have become consolidated, when passive movements may be commenced. Active movements of the fingers should be undertaken as soon as the patient can move without pain.

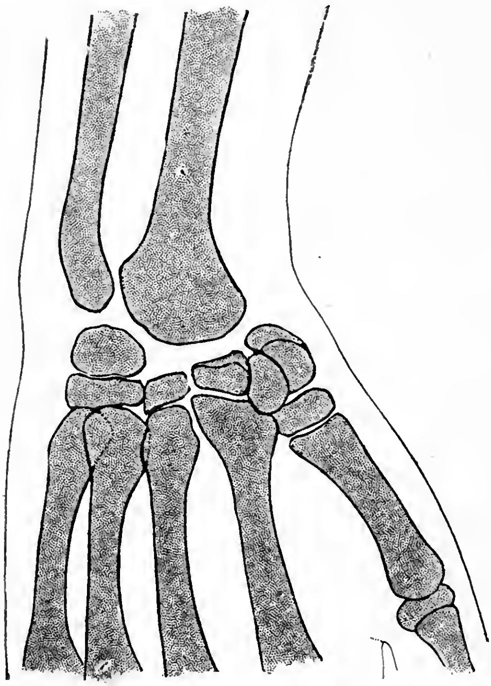

FIG. 462.—RESULT OF PARTIAL EXCISION OF WRIST (SKIAGRAPH).

All the carpal bones of the first row have been removed except the pisiform, and part of the second row also. The functional result was excellent.

For some time after the splint is left off, the patient should wear a leather support, and should be persistent in his attempts to exercise the wrist and fingers and to increase the range of their movements.

Results.—The results of this operation are on the whole satisfactory. A shortened or somewhat dwarfed hand is left, but, provided all the disease has been removed, sound healing should occur. The patient can write with the hand, and perform most of the normal movements; sometimes even a really strong limb is obtained. The patient should be under observation for a long time, in order that any fresh development of the tubercular disease may be dealt with at once. A successful excision of the wrist contrasts well with that of any other joint, and is infinitely preferable to an artificial hand.

2. EXCISION OF THE ELBOW

This operation consists in the removal of the lower end of the humerus and the upper extremities of the radius and ulna.

It is performed for cases of tuberculous disease of the joint which have resisted milder treatment; for certain cases of injury, notably gunshot wounds; for the relief of ankylosis when in a faulty position; and for some examples of unreduced dislocation. The object aimed at is the production of a movable joint. Of the various conditions for which the operation is performed, tuberculous disease is by far the most frequent. With regard to ankylosis of the elbow, unless this has been allowed to occur in the extended position, it is rarely the case that an excision is justifiable. A firmly ankylosed elbow at or near 90° of flexion will probably be so useful that no operation should be thought of. Excision in such cases of bony ankylosis is an extremely difficult proceeding—far more so than in the ordinary tubercular cases.

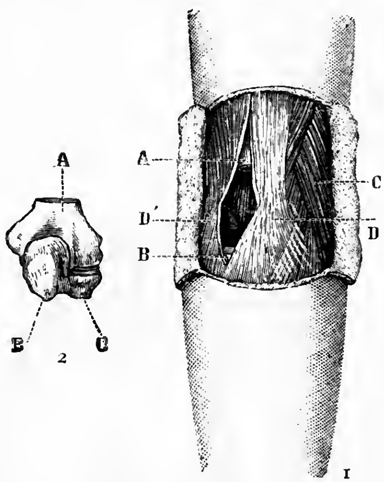

FIG. 463.—1, RIGHT ELBOW AFTER EXCISION BY DORSAL INCISION. (*After Farabeuf.*)

A, Humerus; B, Ulna; C, Supinator longus and radial extensor of the carpus; D, Outer expansion from triceps tendon; D′, Inner expansion from the same.

2, PARTS REMOVED IN THE EXCISION. A, Humerus; B, Ulna; C, Radius.

The three most important muscles in relation to this operation are the biceps, the brachialis anticus, and the triceps. The insertion of the two first-named muscles should never be divided. The biceps is inserted into the tubercle of the radius, the brachialis anticus into the anterior surface of the ulna at the root of the coronoid process. A section of the ulna sufficiently low to include the whole of the coronoid process will not involve a sacrifice of the insertion of the brachialis anticus. The triceps insertion occupies not only the upper flat surface of the olecranon, but also a considerable portion of each of the sides of that process.

From the triceps tendon come off two considerable lateral expansions, which descend obliquely to join the deep fascia of the forearm (Fig. 463). Of these the internal is insignificant. The external expansion is, however, considerable, and should always be saved, as

it enables the triceps to retain a hold of the forearm, even after the olecranon has been removed.

The anconeus and supinator brevis muscles must be seriously disturbed in any excision of the elbow. The other muscles in very immediate relation with the joint are the extensor carpi radialis brevior and the extensor carpi ulnaris.

One danger in this operation is division of, or damage to, the ulnar nerve as it lies in the groove between the olecranon and the internal condyle.

Another nerve which is readily injured in this operation is the

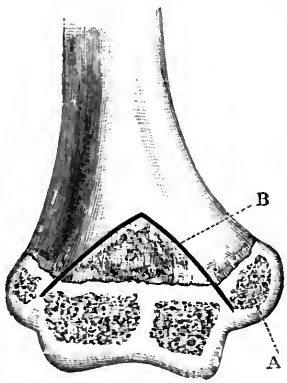

FIG. 464.—DIAGRAM OF HUMERUS AT AGE OF 15.

A, Internal epicondyle; B, Line of attachment of anterior part of capsule.

FIG. 465.—UPPER END OF THE RADIUS IN A SUBJECT AGED 15. (*After Ollier.*)

A, Epiphysis; B B′, Synovial membrane.

posterior interosseous, which is placed in jeopardy when the upper end of the radius is being bared.

The lower epiphysis of the humerus is of large size, and contains four separate osseous nuclei. The main mass of the epiphysis joins the shaft about the sixteenth or seventeenth year, the nucleus forming the internal condyle joins at the eighteenth year. That part of the epiphysis which forms the radial condyle and the trochlea is within the capsule of the joint. That part which forms the two epicondyles is without the synovial cavity (Fig. 464).

The upper epiphysis of the radius forms the head of the bone, is within the synovial cavity of the joint, and joins the shaft between the sixteenth and seventeenth years (Fig. 465).

The olecranon process is mainly formed from the diaphysis; indeed, more than three-fourths of its greater sigmoid cavity belongs to that segment of the bone.

Excision through a Posterior Median Incision.—The patient lies upon the back, with the body close to the edge of the table. The surgeon stands on the side that is to be operated upon. An assistant is placed on the opposite side of the table—i.e. upon the patient's sound side—and holds the limb. The upper arm should be vertical, or at right angles to the surface of the table; the elbow should be a little flexed, and the forearm be carried across the patient's chest, so that the elbow projects prominently outwards (Fig. 467). In dealing with the right joint the operator should stand by the patient's loins; and in dealing with the left, well to the outer side of the trunk. A second assistant, standing on the opposite side, can help to steady the limb by grasping the arm and forearm as he leans over the body; and a third helper, placed to the surgeon's left, should be prepared to assist in retracting the divided parts.

In this attitude it will be understood that the ulna and olecranon will be uppermost.

Narrow-bladed rectangular retractors made of the stoutest steel are requisite.

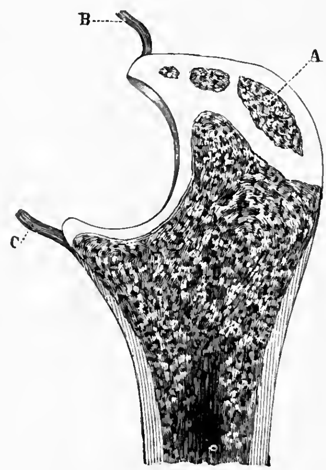

FIG. 466.—UPPER END OF THE ULNA IN A SUBJECT AGED 15. (*After Ollier.*)

A, Epiphysis; B, Posterior Ligament; C, Anterior Ligament.

The Incision.—The skin-incision is about four inches in length, is in the long axis of the forearm, and is so placed as to cross the centre of the olecranon fossa of the humerus, and to run along the middle of the olecranon process, and then follow the crest or posterior border of the ulna (Fig. 468).

The centre of the incision should correspond to the tip or summit of the olecranon, so that two inches of the cut will be over the humerus and two inches over the olecranon and ulna. The stout short-bladed excision knife may be carried at once down to the bones, cutting on to the olecranon, bisecting the triceps tendon, opening the articulation through the posterior ligament, and reaching the back of the humerus.

As the cut will be made from "above downwards," it will be seen that in the position occupied by the limb the knife will cut first upon the ulna, which is uppermost, and then upon the humerus (Fig. 467).

Clearing of the Olecranon and the Condyles of the Humerus.—In clearing the bones for excision, the following rules should be observed :—(1) The surgeon should keep the knife well down upon the bone, and his incisions should be short and made with force, and the edge of the blade be kept turned towards the bones. (2) The periosteum should be separated to as great an extent as possible, and all ligamentous connections should

FIG. 467.—EXCISION OF THE ELBOW: THE CLEARING OF THE HUMERUS.

be spared. The operator should aim at leaving the bones absolutely bare. (3) The rugine and the elevator should be freely used, while the knife is employed sparingly. The left thumbnail must be used with vigour to retract the tissues as soon as they are separated, and the surgeon may expect that the thumb of his left hand will remind him of the operation for many days after. Good retractors must also be employed at every step. The main feature of the operation is the efficient peeling of the olecranon and the irregularly shaped humerus.

The inner part of the wound is first dealt with.

The inner half of the triceps tendon is peeled from the olecranon with as much periosteum as possible. The hollow between

the olecranon and the internal condyle is now cleared until that process of bone is reached and is left bare and projecting.

If the operator keep close to the bones, and observe the three rules just laid down, there is no reasonable danger of wounding the ulnar nerve. The internal lateral ligament is stripped off from both humerus and ulna, and the periosteum is so separated as to carry with it the origin of the flexor muscles.

The surgeon now turns to the outer part of the incision, separating the tissues on that side until the outer epicondyle is reached and laid bare. In this stage of the operation the outer half of the triceps tendon will be separated and drawn aside without severing its connection with the deep fascia of the forearm, the anconeus will be raised from the ulna, the external lateral ligament and the origin of the mass of extensor muscles will be separated from the humerus, and the supinator brevis will be turned well aside. Here again strong retractors are of great service (Fig. 469). It is during this part of the procedure that damage may be done to the posterior interosseous nerve.

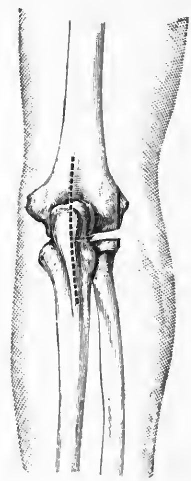

FIG. 468.—EXCISION OF THE ELBOW: MEDIAN VERTICAL INCISION.

On both sides of the humerus the muscular origins should not be stripped off the bone higher than is required to clear the latter for the saw. It is hardly ever necessary to divide the bone much above the widest part—i.e. the level of the epicondyles.

The bones of the joint are now free of one another except upon their anterior aspect.

Sawing Off of the End of the Humerus.—The elbow should now be fully flexed, and without much difficulty the lower end of the humerus can be made to project into the wound. The patient's hand should then be placed in the prone position upon the operating-table, close to the patient's head upon the affected side. In this attitude it can be firmly held, the lower ends of the radius and ulna being fixed rigidly upon the table. The assistant who grasps the upper arm should project the lower end of the humerus upwards. This portion of bone is now cleared

of its few attachments in front, and is bared as high up as is necessary. The surgeon then grasps the bone with lion forceps held in the left hand and maintained vertically, as if he would draw the bone directly upwards (Fig. 469). A narrow saw with a movable back is applied horizontally to the lower extremity

FIG. 469.—EXCISION OF THE ELBOW: SAWING OFF THE HUMERUS.
(*Modified from Farabeuf.*)

of the bone so fixed, and the excision of the humerus is completed. The saw-line generally crosses the bone at right angles to its long axis, and just below the tips of the condyles. In using the saw a metal retractor or spatula should be employed to hold back and retract the soft parts. A strip of bent metal of the form shown in Fig. 469 answers admirably for this purpose.

Sawing Off of the Ends of the Radius and Ulna.—While the limb is in the same position the assistant who is fixing the forearm relaxes his hold, and, forcing the bones of that part of the limb upwards, makes them in turn protrude prominently in the wound. The ulna is grasped with the lion forceps, which are again held vertically, as if to draw the bone directly upwards; and the metal spatula having been applied, the saw is used horizontally upon the base of the process, a slice of the upper end of the radius being removed at the same time (Fig. 463).

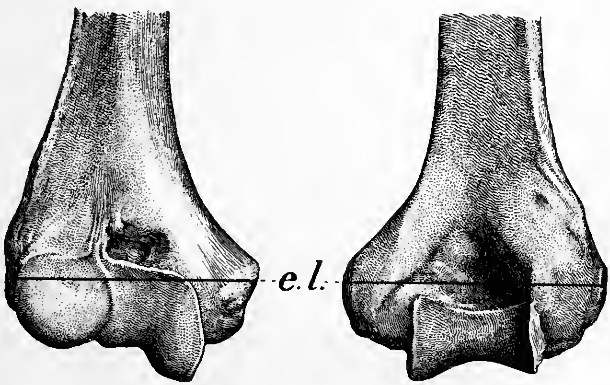

FIG. 470.—FRONT AND BACK VIEWS OF HUMERUS.
The line *e. l.* indicates the usual level of the saw-cut in excision of the joint. The section may require to be made higher up in some cases.

The wound is washed out, is adjusted with sutures, and a drainage-tube is inserted.

After-treatment.—After the operation the limb must be placed upon a suitable splint, and the bones so adjusted that the greater diameters of the bony surfaces correspond and do not cross. The hand should be in the mid-position between pronation and supination, and the elbow be very slightly bent—so slightly that the forearm will be nearer to the extended posture than to the position it occupies when at right angles to the arm. The precise angle recommended by most surgeons is one of 135°.

Very many forms of splint have been devised. The main requirements of such appliances are that they be light, strong, rigid, easily kept clean, and do not interfere with the drainage

and dressing of the wound. In many cases a splint may be dispensed with, the support of the dressings and a pillow being sufficient.

Mason's splint (Fig. 471) answers its purpose well, and also permits the joint to be exercised without the splint being removed. The fingers should be free. The splint and limb may be at first suspended from a cradle, or supported upon a pillow with sand-bags.

It must be borne in mind that there is some disposition for the bones of the forearm to be displaced backwards, that too wide a distance between the bones may lead to a flail-like joint, and that if, on the other hand, the sawn surfaces be kept in close contact, in young subjects, bony ankylosis may ensue. The relative position of the bones can always be estimated by a skiagram.

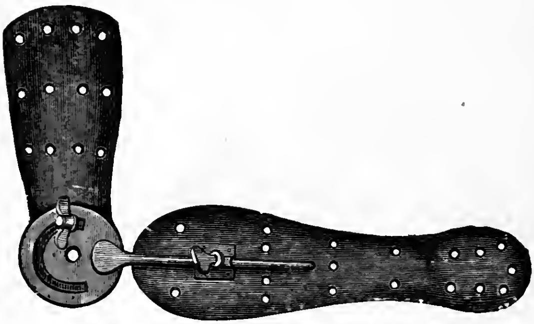

FIG. 471.—MASON'S SPLINT FOR EXCISION OF THE ELBOW.

In general terms, it may be said that to ensure a false joint the bones should be separated for the distance of half an inch.

When also a considerable quantity of bone has been removed, the use of a rectangular splint from the commencement is advised by many.

Passive movements of the fingers and shoulder, and flexion and extension of the wrist, should be commenced as soon as possible after the operation—possibly by the third day—and should be persevered with daily. Passive movements of the elbow may be commenced about the tenth day, provided that the healing process has proceeded favourably and the measure can be borne by the patient without undue pain. In children such movements may at first be required to be carried out under an anæsthetic.

When four or five weeks have elapsed, the forearm may be gradually brought up until it forms a right angle with the arm.

At the end of six or eight weeks the splint may be dispensed with, and the movements of the elbow should be free. Active movements, aided by massage and galvanism, should now be advised ; and within four months from the time of the operation the new joint should have acquired solidity and be capable of exhibiting a free and extensive range of movements.

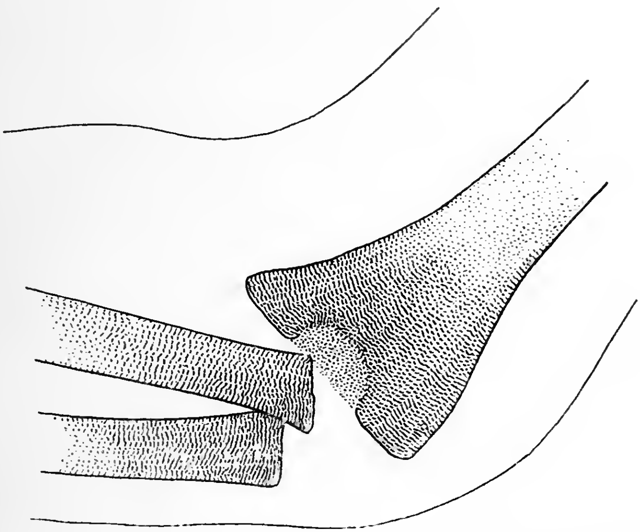

FIG. 472.—EXCISION OF ELBOW-JOINT: RADIOGRAPH SHOWING THE HUMERUS, RADIUS AND ULNA.

From a case operated on two years previously. The amount of bone removed is about the average.

Results.—Excision of the elbow has proved on the whole to be very satisfactory, and in a large proportion of the more favourable cases the results have been most admirable. Even if ankylosis occurs at a right angle, the limb is in a better condition than it was while the seat of disease. In the more unfortunate instances the repair is imperfect for one reason or another, and a very loose false joint, resulting in a flail-like limb, is the final production. Even in such a case a good deal may be done by means of a suitable apparatus.

CHAPTER V

EXCISION OF THE SHOULDER AND OF THE SCAPULA

I. EXCISION OF THE SHOULDER

THIS operation consists of an excision of the upper end of the humerus. The shoulder-joint is not excised—in other words, that portion of the scapula which supports the glenoid fossa is not sawn away with the articular segment of the humerus. Portions of bone may be gouged from the glenoid fossa, but more than that is seldom done. The operation is usually performed for tuberculous disease, and its subjects are, as a rule, of more advanced age than in the case of other excisions, such as those of the knee and elbow. Good results have been obtained even in patients over fifty years of age. The operation is occasionally performed for old unreduced dislocation where the new joint is a very poor one.

The object attained is the establishment of a false joint. It is important to retain the attachments of the rotator muscles into the tuberosities, and to damage the deltoid as little as possible. Hence an incision through the anterior border of the latter muscle is to be selected.

Anatomical Points.—The shoulder-joint is very simple in its construction, and the bony points in the vicinity of the joint are easily made out. The part of the humerus felt beneath the deltoid muscle is not the head, but the tuberosities—the greater tuberosity externally, the lesser in front. A considerable portion of the head of the humerus can be felt through the capsule when the fingers are passed high up into the axilla and the limb is abducted. The head of the bone faces very much in the direction of the internal condyle.

When the arm hangs at the side, with the palm forwards, the bicipital groove looks directly forwards.

The position of the coraco-acromial ligament may be defined,

and a knife thrust through the middle of it would strike the biceps tendon and open the shoulder-joint.

The groove between the pectoralis major and deltoid muscles is usually to be made out. In it run the cephalic vein and a large branch of the acromio-thoracic artery. Near the groove, and a little below the clavicle, the coracoid process may be felt. The process, however, does not actually present in the interval between the two muscles, but is covered by the front edge of the deltoid.

The circumflex nerve and posterior circumflex artery cross the humerus in a horizontal line that is about a finger's-breadth above the centre of the deltoid muscle as measured from the acromion to the deltoid insertion. The artery is usually above the nerve. The point at which these structures cross the humerus about corresponds to the surgical neck. It is important not to injure the posterior circumflex artery during the operation, as this accident has even compelled amputation. As the wound will probably be close to its origin from the axillary, the hæmorrhage will be as severe as from a wound of the main vessel and as difficult to control.

The capsule of the joint is very lax, and is attached to the humerus along the lines of the anatomical neck.

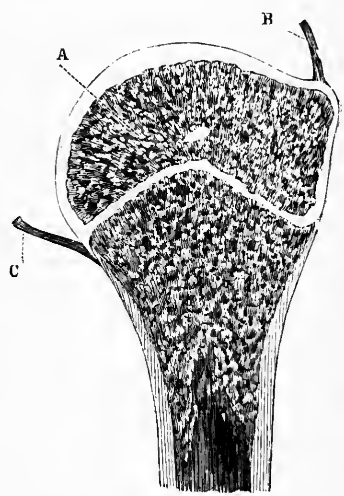

FIG. 473.—UPPER END OF THE HUMERUS IN A SUBJECT AGED 16. (*After Ollier.*)

A, Epiphysis; B, Upper part of capsule; C, Lower part of capsule.

The line of the epiphysial cartilage is shown in Fig. 473. The inner part of the cartilage is just within the capsule; the outer, anterior and posterior, parts are entirely subperiosteal. The epiphysis is united with the shaft at about the age of twenty years.

The surgical neck is situated between the bases of the tuberosities and the insertions of the latissimus dorsi, teres major, and pectoralis major muscles (Fig. 474).

To the greater tuberosity is attached the supraspinatus, infraspinatus, and teres minor; to the lesser process, the subscapularis.

The Operation by an Anterior Incision.—The procedure here described is of the "open method" order.

The patient lies upon the back, close to the edge of the table, with the shoulders well raised.

The elbow is flexed, and is carried a little from the side. The assistant who holds the limb sits or stands by the patient's loins. The surgeon takes up a position to the outer side of the shoulder and faces the subject. A second assistant stands behind the shoulder, facing the operator. The bony points about the joint should be defined.

The Incision.—The incision, which is three and a half to four inches in length, commences at the outer side of the tip of the coracoid process, and is carried downwards and a little outwards to follow the inclination of the anterior margin of the deltoid muscle (Fig. 475, A).

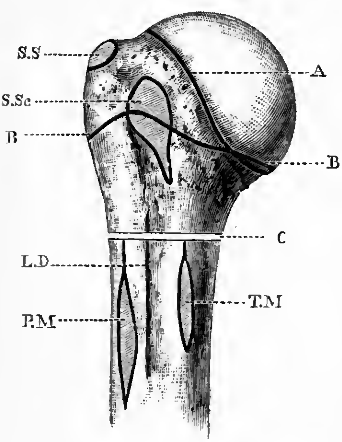

FIG. 474.—DIAGRAM OF THE UPPER END OF THE HUMERUS.

A, Attachment of capsule and anatomical neck; B, Line of epiphysis; C, Surgical neck; S.S, Supraspinatus; S.SC, Subscapularis; L.D, Latissimus dorsi; P.M, Pectoralis major; T.M, Teres major.

The knife is carried straight down to the joint, the coraco-acromial arch is exposed, and the capsule of the joint laid bare in the line of the incision. The biceps tendon is next sought for, and the capsular ligament is opened vertically just to the outer side of the tendon. It is most conveniently incised from below upwards.

Separation of the Outer Margin of the Wound.—The operator now proceeds to clear the tissues from the bone upon the outer side of the wound. In the case of the right limb this will be the left margin of the wound, and in the case of the left limb the right margin.

The parts are well retracted with the left thumb, aided, when required, by retractors. The surgeon uses a blunt-pointed knife, and separates the soft parts from the upper end of the humerus by cutting on to the bone.

The instrument should be kept as close to the bone as possible. As the separation proceeds, the assistant rotates the

humerus inwards, while at the same time he depresses the elbow and forces the head of the bone forwards.

The surgeon clears the capsule from the outer part of the bone, but on reaching the external tuberosity he should carefully preserve, if possible, the insertions of the supraspinatus, the infraspinatus, and the teres minor. Even if it be necessary to raise either of these muscles, the continuity of its insertion with the periosteum should be preserved.

Separation of the Inner Margin of the Wound.—The limb is restored to the position it originally occupied, and the surgeon proceeds to clear the bone upon its inner aspect in the manner just described. The humerus is rotated outwards as he proceeds, and when the lesser tuberosity is reached, the subscapularis insertion is drawn downwards after being partially divided or peeled off the bone.

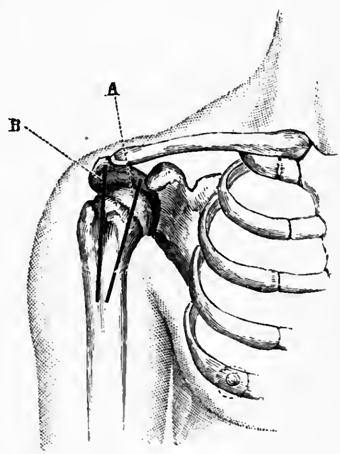

FIG. 475.—EXCISION OF THE SHOULDER.
A, Incision of Bauden, Hueters, and Ollier; B, Vertical incision of Langenbeck and others.

In this stage care must be taken of the biceps tendon, which should be drawn aside.

Clearing of the Neck of the Bone.—The biceps tendon is displaced inwards. The elbow is flexed, and the arm is held vertically (i.e. at right angles to the table), and is thrust upwards so that the head of the bone is exposed while the two edges of the deep wound are forcibly retracted. The posterior part of the neck of the bone is cleared, and the parts are prepared for the actual resection. It will be understood that this is performed while the head of the humerus is still in the joint-cavity. Formerly it was recommended that the humeral head should be thrust through the wound, but this cannot be effected unless the rotator and small elevator muscles have been wholly divided.

Excision of the Head of the Humerus.—This can be best done with a broad chisel or Hey's saw. All the diseased articular surface should be cut away, and if the operation is being performed

for tuberculous disease it will probably be found that this extends to some depth into the head of the bone. As much of the latter as can safely be left should be preserved, and it is a good plan to make the section slightly convex upwards (*see* Fig. 474). I (J. H.) have found a chisel and gouge the most convenient instruments.

The glenoid cavity is examined, and its diseased surface gouged away. The skin incision is closed with sutures, and the limb placed in position.

It should be noted that, so long as all diseased bone and synovial membrane is removed, the insertions of the rotator muscles should be interfered with as little as possible. The synovial pouches in connection with the subscapularis and biceps

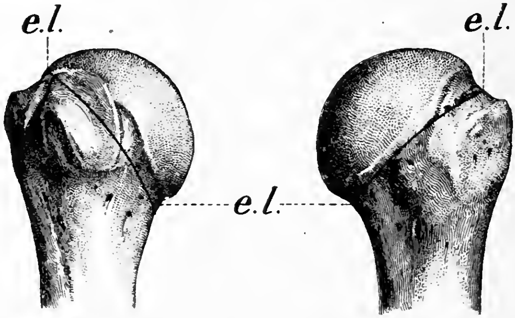

FIG. 476.—LINE OF SECTION OF HUMERUS IN EXCISION (*e.l.*).

muscles should be carefully dissected out. If the reflected tendon of the biceps is obviously diseased it should be cut away; sometimes it has already been destroyed. When possible, however, it should be preserved.

Comment.—This procedure can claim to be the best and the most generally adopted method of excising the shoulder.

The capsule is readily reached, the biceps tendon is easily dealt with and protected from hurt, and no injury is inflicted upon the most important muscle of the shoulder—the deltoid. The wound is not well adapted for drainage, but a tube can be readily passed through a counter-puncture made through the back of the deltoid muscle. The incision described is that of Bauden, Hueter, and Ollier (Fig. 475, A).

Langenbeck's incision is placed more to the outer side, and

has for its starting-point the acromio-clavicular joint (Fig. 475, B). No especial advantage appears to have been claimed for a skin-wound so placed, while it has the disadvantage of inflicting more serious damage upon the deltoid muscle.

In operating upon the left side it may be more convenient to clear the left side of the wound first.

As little bone should be removed as is possible. In most instances it is practicable to make the section at the anatomical neck as described. It will obviously be a great gain if either of the tuberosities can be saved. The higher the saw-cut, the wider the section. In cases of advanced disease it may, however, be necessary to remove both tuberosities, making the section at the "surgical neck" or even below. The functional result will then be inferior.

A slight modification in closing the wound is advocated by M. Péraire. It consists in converting the vertical wound through the soft parts into a horizontal one by deep sutures. Péraire advises the same course with regard to the skin. The object is to draw the humeral end upwards towards the glenoid cavity.

In children only very little of the bone can be removed without taking away the whole of the epiphysis.

So far as the growth of the arm is concerned, this is the most important epiphysis in the limb.

After-Treatment.—The upper end of the humerus is to be brought into contact with the glenoid fossa. The arm is secured to the side, the hand rests in a sling. A large pad of cotton-wool is introduced into the axilla. This pad is intended to support the bone, to assist in fixing the parts, and to counteract the tendency which will be exhibited for the upper end of the humerus to be drawn inwards under the coracoid process. This displacement is especially apt to occur when the external rotator muscles have been divided, and there is little to withstand the action of the pectoralis major and latissimus dorsi. The size of the pad must be regulated according to the needs of the case. It should be of triangular outline, with the base uppermost.

The pad is likely to fail, if it fail at all, from being too small rather than too large. No splint is required.

Passive movements of the fingers, wrist, and elbow may be commenced within a day or two of the operation. Very gentle

passive movements of the shoulder may be first attempted at the end of some fourteen days. These movements should consist of flexion and extension of slight rotation, and of still slighter abduction. The latter position tends to throw the end of the bone inwards—or, rather, to assist the disposition to that deviation. Massage, electricity, and active movements will follow in due course. The arm may be allowed to hang, with no other support than a sling, at the end of four or five weeks.

Results.—The results of this operation may be considered to be very satisfactory. The mortality of the operation is slight.

More than two-thirds of the subjects of the operation appear to recover with quite useful limbs. In many instances the restoration of function has been remarkable. As a rule flexion and extension are freely performed, and the patient can lift considerable weights.

Adduction also is well accomplished. On the other hand, rotation movements and abduction are feebly performed. Much will depend on the level of section of the bone and the extent to which the insertion of the muscles and the periosteum have been preserved.

2. EXCISION OF THE SCAPULA

In the larger number of cases of excision of this bone the operation has been performed for tumour. Excision has also been carried out in the treatment of caries or necrosis, and for severe injury.

In the greater proportion of the instances the excision has been partial.

Partial excisions, such as concern the removal of the acromion, or of portions of the spine for necrosis, hardly come into the present category. These operations involve little more than the removal of sequestra.

Anatomical Points.—The precise attachment of the various scapular muscles must be borne in mind. It is well to note also the dense fascia which covers and binds down the muscles of the supraspinous and infraspinous regions. The exact attachments of the capsular ligament, of the conoid and trapezoid ligaments, and of the coraco-humeral ligament, are material to this operation.

The importance of saving the glenoid segment of the bone and the acromion and coracoid processes will be obvious.

A line drawn from the suprascapular notch through the great

scapular notch marks the site of the surgical neck of the bone, and isolates the glenoid cavity and coracoid process. The periosteum is thick and strong over the spine, the acromial and coracoid processes, and along the borders.

The main vessels to be noted in connection with the operation are—(1) the suprascapular, at the superior border of the bone, where it crosses over the ligament of the suprascapular notch; (2) the posterior scapular, which follows the vertebral border of the bone under cover of the rhomboids; (3) the subscapular, which runs along the lower border of the subscapularis muscle to reach the interior angle; (4) the dorsalis scapulæ, which crosses the axillary border of the bone to enter the infraspinous fossa; and (5) the acromial branches of the acromio-thoracic artery, which ramify about the acromion process.

The largest of these vessels are the dorsalis scapulæ and the subscapular. The former vessel crosses the axillary border of the scapular at a point on a level with the centre of the vertical axis of the deltoid muscle.

Operation.—The patient lies close to the edge of the table, and upon the sound side. The back of the scapula is well exposed. The following incisions are made: One follows the vertebral border of the bone from the superior to the inferior angle; it is to the outer side of the border, and is parallel with it. A second incision commences over the acromio-clavicular joint, and is carried along the acromion and spine to meet the first incision at a right angle.

Two flaps are thus formed—an upper and a lower one. The operation is carried out in the following steps:—

(1) The upper flap is first turned up, and the trapezius muscle is divided along its line of attachment to the bone.

(2) The lower flap is then turned up, and the deltoid muscle is in like manner divided at its insertion.

(3) The patient's hand is drawn as far as possible over the shoulder of the sound side, to bring into prominence the vertebral border.

All the muscles attached to this border are severed close to the bone. The posterior scapular artery is ligatured.

The free edge of the scapula is dragged towards the operator, and the serratus magnus is cut through.

(4) While the limb is still in the same position the superior border of the bone is cleared and the suprascapular artery is ligatured.

(5) The patient's hand is now dragged down towards the hip. The acromio-clavicular joint is opened. Any remaining attachments of the deltoid and trapezius are divided. The conoid and trapezoid ligaments are cut from behind, close to the clavicle.

The limb is so manipulated that the coracoid process is turned towards the operator. The muscles attached to it (biceps, coraco-brachialis, pectoralis minor) and the remaining ligamentous fibres are divided.

(6) The capsule is divided with the muscles around it, viz. the supraspinatus, infraspinatus, and subscapularis. The scapular heads of the biceps and triceps are cut. The bone is now only connected by means of its axillary border.

(7) The muscles of the axillary border—the teres major and minor—are divided near to the scapula.

The subscapular artery is sought for and ligatured.

The scapula is at this last stage in such a position that the muscles may be cut from before backwards, and the trunk of the subscapular artery may be exposed before it gives off the dorsalis scapulæ.

Comment.—The steps of the operation need not follow the above course, but may be varied as found most convenient. It is very desirable, however, that the muscles of the axillary border, and the subscapular artery, should be left to the last.

The great risk throughout the operation is from hæmorrhage; and as the excision is most usually carried out for a sarcomatous growth, the vessels are numerous and of large size. It is essential that compression of the subclavian artery be maintained, and, if necessary, a special incision may be made over that vessel in order that it may be more conveniently reached.

The main vessels may be exposed and ligatured before they are cut. The other bleeding arteries must be clamped as divided.

It is assumed in the above description that the operation is performed for tumour, and consequently the deeper muscles of the scapula—namely, the subscapularis, supraspinatus, and infraspinatus—are removed with the bone, their tendons of insertion alone being left.

The subperiosteal method has been advised in performing this excision. It may possibly be carried out when dealing with some small portion of the bone—as when the operation is performed for limited necrosis or caries—but in the great majority of instances, and certainly in all operations for tumour, the method is entirely out of place.

The procedure is slow and tedious, and enormous masses of quite useless muscle are left attached to the humerus. If the excision be for a growth, the more completely the bone is removed the better.

In dealing with cases of new growth the removal of a part of the scapula is a less satisfactory proceeding than the removal of the whole.

The instances, however, are not few in which the glenoid cavity may be saved.

After-Treatment.—A drain should be introduced into the lower part of the wound for the first twenty-four or forty-eight hours. The patient must occupy the recumbent position, with the shoulder and upper limb secured upon a pillow. As soon as healing is sound the limb may be supported in a sling.

Results.—The utility of the limb preserved is often remarkable. Patients have recovered with considerable power in the extremity, have been able to lift weights and to follow a light occupation.

In Mr. Symonds' case (*Clin. Soc. Trans.*, vol. xx., page 24) the patient was able to do all the lighter work of a carpenter, including the use of a plane. Overhead work he could not manage.

CHAPTER VI

EXCISION OF CERTAIN TARSAL BONES, OF THE ANKLE-JOINT, ETC.

I. EXCISION OF CERTAIN BONES OF THE TARSUS

CUNEIFORM osteotomy of the foot is dealt with in the chapter on Osteotomy for Club-foot (page 701).

Excision of certain individual bones of the tarsus is occasionally practised. The operations concern mainly the astragalus and the os calcis.

The cuboid has been removed in the treatment of severe forms of talipes, this bone forming the greater part of the wedge.

Others of the tarsal bones have been removed—or, more accurately speaking, gouged out—through a simple incision, in cases of limited disease.

The Synovial Membranes of the Foot.—In dealing with individual bones of the tarsus, the position and extent of the synovial membranes of the tarsal joints must be borne in mind.

The following are the synovial cavities of the ankle and tarsal joints (Fig. 477): 1. The synovial membrane of the ankle-joint. 2. A sac between the posterior parts of the os calcis and astragalus, behind the interosseous ligament. (Not shown in Fig. 477.) 3. A sac of synovial membrane which is interposed between the anterior parts of the os calcis and astragalus, in front of the interosseous membrane, and between the head of the astragalus and the scaphoid. 4. A synovial membrane between the os calcis and the cuboid. 5. One between the external cuneiform and the cuboid. 6. One between the cuboid and the fourth and fifth metatarsal bones. 7. A sac which separates the internal cuneiform from the first metatarsal bone. 8. A large and most irregular synovial membrane which is insinuated between the remaining bones of the foot, and serves to connect many articulations.

(1) **The Astragalus.**—This bone has been excised for disease, especially for caries following injury in healthy subjects, for gunshot injuries of limited extent, for irreducible or unreduced dislocations of the bone, and for the relief of some forms of intractable talipes.

Anatomical Points.—The bone is in relation with the synovial membrane of the ankle, with that separating the os calcis from the astragalus behind the interosseous ligament, and with that interposed between these two bones in front of the ligament, and between the posterior part of the scaphoid and the astragalus.

The head of the astragalus lies in a socket formed by the scaphoid, the anterior concave facet on the sustentaculum tali, and the inferior calcaneo-scaphoid ligament. This powerful ligament is covered with fibro-cartilage upon its upper surface.

The most important ligament actually attached to the astragalus is the interosseous, which passes between it and the os calcis.

No muscles are connected with this bone.

The astragalus begins to ossify about the seventh month of fœtal life. By the third year it will be about half bone and half cartilage. The osseous tissue occupies the centre, the cartilaginous tissue the surface or periphery.

The dorsalis pedis artery crosses in front of the bone.

The bone is most conveniently reached on the inner side between the tendons of the tibialis anticus and the tibialis posticus, and on the outer side between the tendons of the peroneus tertius and peroneus brevis.

Advantage is taken of these two spaces in the operation which follows.

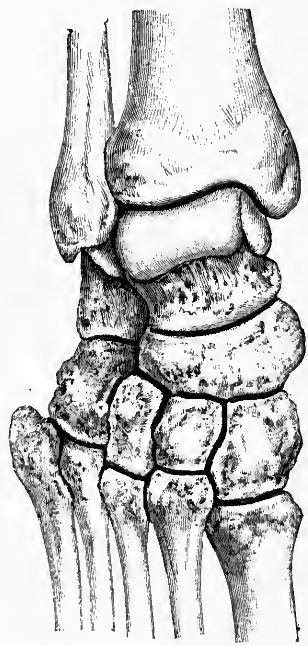

FIG. 477.—ARTICULATIONS OF THE FOOT.

Operation.—The patient lies upon the back, and the foot is so placed as to extend beyond the end of the table. It must be held by an assistant, who can manipulate it as directed.

Two incisions, external and internal, are made. The outer incision is about two and a half inches in length, runs parallel with and just posterior to the tendon of the peroneus tertius, and commences a line or so above the level of the articular margin of the tibia (Fig. 478, A).

A second and much shorter cut starts from the centre of the principal incision, is placed at right angles to it, and ends immediately below the tip of the outer malleolus. The two slight flaps thus

defined are turned aside, and the bone exposed in the interval between the peroneus tertius and peroneus brevis tendons.

The foot is well extended and inverted, and the ligaments which connect the bone with the fibula, tibia, scaphoid, and os calcis are divided so far as they can be reached from the outer side. Retractors are used to protect the tendons, etc.

The inner incision is about two inches in length, and, starting from just below the tip of the inner malleolus, is carried forwards and upwards just in front of the anterior margin of that bone. It will be curved, therefore, with the concavity backwards (Fig. 480, A). The remaining ligaments that hold the astragalus are now divided from the inner side. The surgeon turns finally to the outer wound, and, while the foot is inverted and extended, grasps the astragalus with lion forceps in a vertical direction, and, as Farabeuf expresses it, "whips it out like a molar." The wound will need to be drained, and the limb to be firmly secured upon a splint or in plaster of Paris, with the foot at right angles to the leg.

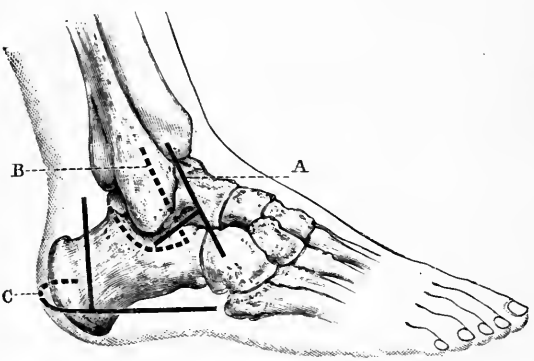

FIG. 478.—A, Excision of astragalus (outer incision); B, Excision of ankle (outer incision); C, Excision of os calcis.

Excellent *results* have followed. A useful but somewhat shortened extremity is produced, and no movement will probably be restored to the ankle-joint. Some surgeons carry out the excision of the bone through a single external wound. The method of operating through a transverse dorsal incision with division—and subsequent suture—of the anterior tendons has little to recommend it.

(2) **The Os Calcis.**—This bone has been removed for disease, and also in some cases of injury. The arrangement of the synovial membranes in relation with the bone is such that mischief commencing in the os calcis is apt to be limited to it.

Anatomical Points.—Three synovial membranes are connected with the surfaces of this bone.

From the upper surface of the os calcis arises the extensor brevis digitorum, and from the plantar surface the first layer of the plantar muscles.

Many strong ligaments are attached to the calcaneum, the most noteworthy being the interosseous, the inferior calcaneo-scaphoid, the long and short plantar, and the prolongations of the lateral ligaments of the ankle-joint.

The principal nucleus of the os calcis appears in the sixth month of fœtal life. Before the age of ten years the posterior part of the bone is wholly cartilaginous. A nucleus appears at that date in this cartilaginous segment, and the epiphysis so formed is united to the rest of the bone about the sixteenth year. The blood-vessels of the bone enter mainly from the inner side.

Operation.—Among the many methods devised for the excision of this bone, the procedure described by Farabeuf appears to be, upon the whole, the best. The incision he recommends is a combination of the horseshoe incision employed by Erichsen and the simpler skin-cut made use of by Ollier.

The operation should be performed, as far as is possible, by the subperiosteal method.

The patient lies upon the sound side, the leg is supported upon a sand-pillow, and the foot, turned well upon its inner border, is free.

The incision, commencing at the base of the fifth metatarsal bone, is carried horizontally backwards just above the margin of the sole, and, passing round the hinder aspect of the heel, ends about one inch and a quarter to the inner side of the median line (Fig. 478, c).

This cut is met by a vertical incision two inches in length, which is parallel to and a little in front of the tendo Achillis. The wound is deepened, and two small flaps are formed. Great care must be taken of the peronei tendons, to which the vertical incision is posterior. The bone is exposed behind the peronei tendons, and the periosteum is incised vertically. With a rugine the periosteum and the associated ligaments are separated from the bone, The outer surface is cleared first, then the posterior surface. The attachment of the tendo Achillis is severed. The foot being placed in the position of talipes varus, the posterior aspect is bared of periosteum as far as it is possible to reach. The anterior portion of the bone is cleared, and the ligaments separated with the periosteum. The same is done with the plantar surface. A certain part of the inner surface can be reached from the posterior aspect.

With care and patience and the use of good retractors the greater part of the bone can be bared through this outer incision, and from this side also the interosseous ligament can be reached and divided. When the os calcis is freed as far as possible, the head or anterior

part must be grasped with lion forceps and the bone dragged outwards with a repeated rotatory movement, the periosteum and ligaments upon the inner surface being separated with the rugine as soon as each part of the as yet untouched district is reached.

Comment.—This operation can be performed upon the cadaver in the systematic manner just described, but in practice so formal a procedure can seldom be carried out.

Sinuses may have to be considered, and carious and broken-down bone to be dealt with. A not inconsiderable part of the bone, in cases of disease, may be removed with the gouge or sharp spoon, and such

FIG. 479.—RESULT OF COMPLETE SUBPERIOSTEAL EXCISION OF THE RIGHT OS CALCIS. The bone has been so completely reproduced that there is a good heel. The foot is, however, shortened. The patient walked well. Note flexion of great toe due to interference with bony canal of flexor longus hallucis.

parts of the compact tissue as are healthy may be left as a kind of thin osseous mould.

The operations which are characterised by the formation of a U-shaped plantar flap are to be condemned, on account of the unnecessary damage they inflict upon the tissues of the sole.

The foot must be fixed at a right angle with the leg, and the heel allowed to be free. An anterior well-moulded metal splint answers the purpose well. After the splint has been applied, the limb must be suspended in a suitable apparatus. This protects the foot from any pressure, and allows efficient drainage to be carried out.

As soon as possible a plaster-of-Paris case should be applied, as then the patient can get about feebly without risk.

The result of the operation is fairly good, though the os calcis is a more important member of the foot-bones than the astragalus, and can

be less easily spared. One of us (J. H.) has reported a case in which almost perfect reproduction of the whole bone, including the sustentaculum tali, followed operation, and in which the lad walked quite well on his new heel. But this case was exceptional in that it was done for necrosis and the periosteal sheath could be preserved.

2. EXCISION OF THE ANKLE-JOINT, ETC.

This excision is of but limited application, and is rarely performed. In the first place, the modern improvements in the methods of treatment are such that a large proportion of the cases of disease of the joint yield to simple measures.

In the second place, amputation of the foot leads to very admirable results, and the excision of the ankle must have a very happy termination if it can yield a more useful extremity than that left after a successful Syme's amputation.

In not a few cases the disease has extended so far beyond the actual area of the ankle-joint that the operation of excision cannot be entertained.

The after-treatment of these excision cases is difficult and anxious, and demands long-continued care.

The ankle has been excised in many cases of injury, notably in compound dislocation and in instances of complex fracture. Here also the position of this class of case has been very materially altered by the modern methods of wound-treatment, and many a foot which twenty years ago would have been amputated or treated by excision is now saved.

The excision of the ankle to remedy deformity resulting from malunited fracture—e.g. severe Pott's fracture—is in the present day usually replaced by some form of osteotomy, either through the tibia and fibula immediately above the ankle, or, it may be, through the internal malleolus and the fibula about the site of its former fracture.

In dealing with excision of the ankle for disease, Prof. Howard Marsh writes: "It is but seldom performed; and when it is performed, the result is usually unsatisfactory."

The Operation.—The patient lies upon the back, with the foot and leg supported upon a firm sand-pillow. Two vertical lateral incisions are made. The leg and foot should be rendered bloodless by the application of Esmarch's tourniquet, otherwise it will be impossible to dissect out thoroughly all the diseased tissues in a case of tuberculous ankle.

1. *The Outer Incision.*—The foot being turned over upon its inner side, a vertical incision some three inches in length is made along the anterior part of the fibula to a point a little below the tip of the malleolus. Thence it is made to curve around the malleolus, and ascend for about one inch along its posterior border (Fig. 478, B).

2. *The Removal of the External Malleolus.*—The fibula is exposed, and its periosteum divided in the long axis of the bone. The membrane is then separated from the bone by the rugine in an anterior and a posterior direction.

The ligaments attached to the malleolus are separated as encountered. The external lateral ligament is divided vertically, so that its anterior segment will go with the anterior layer of separated periosteum, and its hinder segment with the posterior layer.

With the curved rugine the greater part of the circumference of the shaft of the bone can be bared about the saw-line.

The fibula is then divided with either a chisel or a saw about one inch above its extremity. The divided end is seized with lion forceps, or is drawn outwards with a hook, while its deeper connections are separated with the rugine, aided by the knife.

This part of the operation is very tedious.

The lower end of the fibula is thus removed.

3. *The Clearing of the Tibia.*—As much of the anterior and posterior surfaces of the tibia as can be reached through the outer cut is bared of periosteum by means of the rugine, the anterior and posterior ligaments of the ankle being elevated with the periosteal layers. In this part of the operation care must be taken not to open the sheaths of the tendons.

4. *The Inner Incision.*—The foot is turned upon its outer side, and an incision about three inches long is made along the inner surface of the tibia and in the long axis of the bone. The cut ends at the tip of the inner malleolus. A curved or transverse incision (Fig. 480, B) may be made to meet the lower end of this wound at right angles.

5. *The Removal of the Articular Surface of the Tibia.*—The periosteum of the tibia is incised vertically, and that membrane is peeled from the bone so that it may be continuous with the periosteo-capsular layers already separated upon the outer side. The internal lateral ligament is divided vertically in the manner already described with regard to the outer ligament.

As soon as the tibia is sufficiently free, the malleolar end of it is made to project a little through the wound, and while the soft parts are well protected with retractors, the bone is divided horizontally with a key-hole saw. This section removes the internal malleolus

and the diseased articular surface of the tibia. A thin layer of bone should be removed with the saw, and, if necessary, any patches of caries should be further gouged out. The fragment is grasped with lion forceps and removed.

6. *The Sawing of the Astragalus.*—The surgeon finally turns once more to the outer incision, and through that wound removes with the saw as much of the upper part of the astragalus as is necessary. The section should be horizontal. If it is absolutely necessary, the whole of the astragalus may be removed through the external incision. The best result will, however, be obtained if firm bony ankylosis occurs between the cut surface of the tibia and astragalus, and hence the less that is removed of that bone the better, so long as all tuberculous foci are dealt with.

7. *The Excision of the Tuberculous Synovial Membrane, etc.*—This should be carefully and systematically done, the surgeon paying special attention to the joint capsule behind the extensor tendons, the prolongation upwards of the cavity between the tibia and fibula, and to diseased pouches which are often present on either side of the joint. If these latter cannot be dissected out, they must be thoroughly scraped with Volkmann's scoops.

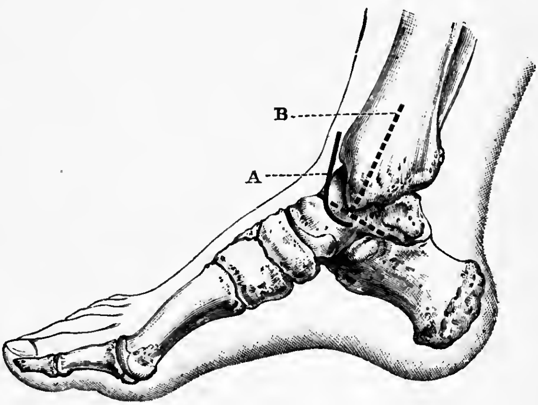

FIG. 480.—A, Excision of astragalus (inner incision); B, Excision of ankle (inner incision).

The tourniquet should then be removed, and the hæmorrhage, chiefly from terminal branches of the peroneal artery in front and behind the joint, should be stopped. Malleolar twigs from both anterior and posterior tibial will also require attention. Finally the cavity is irrigated with warm sterilised water, and any divided tendons sutured with fine silk. Both lateral wounds are sewn up with silkworm gut, the insertion of a small drainage-tube on either side being generally advisable. It can easily be arranged to remove the tubes after forty-eight hours without disturbing the dressings or the position of the foot.

Comment.—The operation just described follows the subperiosteal

method, and in all suitable cases that form of excision should be observed so far as is possible.

The lateral incisions may vary considerably from those described in the text.

The outer incision may follow the posterior border of the fibula, and be made to bend suddenly forwards beneath the malleolus when the tip of that process is reached. This was the outer incision of Moreau. Or a vertical cut so placed may be met by a transverse line which extends as far forwards as the tendon of the peroneus tertius.

The inner incision has been made to form a **U**-shaped flap corresponding in width to the shaft of the tibia, or has assumed something of the outline of an anchor, a vertical cut being joined by a transverse incision at its upper end and a curved one at its lower.

The removal of the entire astragalus is insisted upon by many who advocate the operation in cases of bone disease.

Farabeuf saws through the tibia and fibula together, using a key-hole saw, and protecting the soft parts with retractors.

Most essential is it that every care should be taken of the sheaths of the tendons.

Some surgeons, after the removal of the fibula, saw off the upper part of the astragalus, then make the inner incision, and finally remove the tibial segment.

After-Treatment.—The after-treatment of a case of excision of the ankle is a matter of extreme importance, and may have a greater influence upon the success of the measure than the operation itself. The foot and leg must be fixed in a suitable splint, the line of the new joint being rectangular. A plaster-of-Paris dressing, with windows to permit of drainage and the inspection of the wound, is recommended by many; or in the place of it a special splint of light wire may be employed. It is desirable that the limb, when fixed in the apparatus selected, should be suspended from a suitable cradle.

Great care must be taken to keep the foot in a straight line with the leg, as a lateral deviation of the limb is very easily produced if this point be not strictly attended to. "If motion be sought for, passive movements ought to be commenced very early; but sound ankylosis is the most common and most desirable result."

Results.—The mortality of the operation of excision of the ankle is slight since the introduction of improved methods of treating wounds.

Firm ankylosis is the usual result obtained; and when this has followed, most useful limbs have resulted.

Langenbeck states that in 75 per cent. of the cases with which he has himself dealt, the patient recovered with a useful limb.

The shortening that results is usually slight, not more than one inch, and is compensated for by a thick sole to the boot worn.

In many instances the patient has recovered with a new joint in which a remarkable degree of movement was present.

If the subperiosteal method can be carried out, the reproduction of new bone is often singularly complete. It may be excessive, but even when imperfect the amount of new tissue produced is sufficient to assist considerably in the establishment of a useful limb.

When ankylosis follows, much compensatory movement is generally developed in the mediotarsal joint.

ARTHRECTOMY OF THE ANKLE-JOINT (KOCHER'S METHOD)

By means of a transverse incision on the outer side the ankle-joint may be freely exposed without division of bone. The incision starts from in front over the peroneus tertius tendon, and curves slightly upwards across the external malleolus to reach the outer border of the tendo Achillis. The musculo-cutaneous nerve and the short saphenous vein and nerve are exposed in this incision, and, if possible, are drawn aside. The surgeon then lifts up the extensor tendons and anterior tibial vessels and nerve from the front of the capsule, displacing them inwards as much as possible. The peronei tendons are also elevated and drawn backwards, it being sometimes necessary to divide them (they can be sutured together at the end of the operation). After the capsule of the joint has been freely divided, it is possible by strong inversion of the foot so to dislocate it that the articular surfaces above and below can be thoroughly exposed. The external lateral ligament must, of course, be divided, but the very strong internal ligament is spared. The whole of the diseased synovial membrane, etc., is then dissected out, and the bone gouged or cut away where it is carious; but the malleoli themselves are left, if possible, as their projection prevents any subsequent tendency to lateral displacement. This method is best adapted for cases in which the tuberculous disease has not affected the bone-ends extensively, and after it a certain amount of movement at the joint may be retained.

CHAPTER VII

EXCISION OF THE KNEE

THIS extensive and serious operation has been performed for numerous conditions, but is now limited to the treatment of certain forms of chronic joint disease.

In acute disease it has been unsuccessful, and in the present position of surgery may be regarded as unjustifiable.

It cannot now be demanded in examples of complicated and compound fracture and dislocation.

The results that have attended the operation when performed for gunshot injuries have been such that the measure is considered by most surgeons to be absolutely contra-indicated in these cases.

As a means of treating ankylosis in a deformed position, excision has been almost entirely replaced by osteotomy.

The value of the operation has been the subject of long-continued, elaborate, and voluminous discussion, and the position of the procedure has been substantially modified by improved methods of treating joint affections, by improved means of dealing with wounds, and by the introduction of the operation known as arthrectomy.

Excision of the knee was first deliberately performed by Park in 1781. The patient was the subject of chronic disease of the joint, and an excellent result followed. A less definite operation had been previously carried out by Felkin, of Norwich, in 1762.

For many years subsequently to that date excision of the knee was but very rarely performed, and the operation was regarded most unfavourably. The measure was, however, revived by Fergusson in 1850, and during the twenty or thirty years after this time the operation was taken up by English, French, German, and American surgeons, with a remarkable enthusiasm, and the recorded cases published during the period

named may be counted by hundreds. Of late years a reaction has taken place, and excision of the knee has been condemned as an operation by some authorities. We do not hold this view. Excision of the knee has saved many a useful limb both in childhood and in adult life, and a large experience of the results of the operation has convinced us that with reasonable care in after-treatment they are excellent. It is unfortunate that many cases of tubercular disease of the knee are allowed to progress far too long under various measures of treatment before excision is at last resorted to, perhaps too late.

The result aimed at is the production of a rigid ankylosis in the extended position, and the attempts to obtain a mobile joint have met with very few successes and a very numerous list of lamentable failures. This, however, does not apply to simple arthrectomy of the joint in young subjects. Although this has often failed and necessitated excision or amputation, yet now and then a really brilliant result has been obtained—a sound and yet freely mobile joint.

In young subjects great care must be taken not to encroach upon the lower epiphysis of the femur, which is the most important epiphysis of the lower extremity.

Anatomical Points.—This articulation is the largest in the body, and owes its great strength to the powerful ligaments which unite the two component bones, and to the muscles and fasciæ that surround it. It derives no strength from the shape of the articular surfaces, since they are merely placed in contact with one another.

The axis of the limb is abruptly altered at the knee-joint, the femur inclining inwards from the pelvis, and the tibia being vertical.

The lateral ligaments of the joint are comparatively feeble, the posterior ligament is substantial, and the anterior part of the capsule is formed of a firm aponeurotic expansion. The most powerful and most important ligaments of the joint are the crucial.

The synovial membrane of the knee-joint extends upwards as a large cul-de-sac above the patella and beneath the extensor tendon (Fig. 481). This cul-de-sac reaches a point an inch or more above the upper margin of the trochlear surface of the femur, and is rendered very distinct when the joint is distended with fluid (Fig. 481).

Above the synovial pouch is a bursa which separates the quadriceps

tendon from the femur and is usually over an inch in its vertical measurement.

This bursa communicates with the synovial cavity in about eight cases out of ten.

The upper third of the patellar ligament is in relation with the synovial membrane, from which, however, it is separated by a pad of fat; the lower two-thirds of the ligament are in relation with the bursa between the ligament and the tubercle of the tibia.

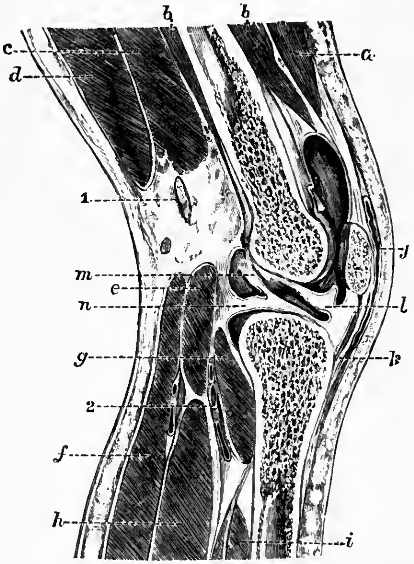

FIG. 481.—VERTICAL SECTION OF KNEE-JOINT DISTENDED WITH FLUID. (*Braune.*)

a, Vastus externus; *b*, Crureus; *c*, Short head, and *d*, Long head of biceps; *e*, Plantaris; *f*, Gastrocnemius; *g*, Popliteus; *h*, Soleus; *i*, Tibialis posticus; *j*, Bursa patellæ; *k*, Ligamentum patellæ; *l*, Ligamentum mucosum; *m*, Anterior crucial ligament; *n*, External semilunar cartilage; 1, External popliteal nerve; 2, Popliteal artery.

A knife passed horizontally backwards at the apex of the patella would, when the healthy limb is extended, just miss the joint-line between the femur and tibia, and would hit the latter bone. If, however, there be any effusion in the joint, or the limb be a little flexed, a knife so introduced would pass between the two bones (Fig. 481).

The irregularity of the synovial cavity lends itself to the collection of masses of diseased tissue within the joint.

In the popliteal space the large bursa which is interposed between the internal condyle of the femur, the inner head of the gastrocnemius, and the semimembranosus, usually communicates with the knee-joint.

The bursa beneath the popliteus tendon usually opens into the superior tibio-fibular joint on the one hand, and always leads into the knee-joint on the other. It serves therefore to establish a communication between these two articulations.

The upper limit of the femoral epiphysis will be represented by a horizontal line drawn across the bone at the level of the tubercle for the adductor magnus. If the whole of the trochlear surface be removed in the excision, the whole of the epiphysis will have been

taken away (Fig. 482). A single nucleus appears in this epiphysis shortly before birth, and joins the shaft about the twentieth year. The epiphysial line is intracapsular.

The limits of the tibial epiphysis are represented behind and at the sides by a horizontal line that just marks off the tuberosities. It includes, therefore, the depression for the insertion of the semi-membranosus, and also the facet for the fibula.

In front the epiphysial line slopes downwards on either side to a point on the upper end of the shin, so as to enclose the whole of the tubercle of the tibia.

The centre joins the main bone at the twenty-first or twenty-second year. The epiphysial line is extra-articular. Farabeuf estimates that in a child of about eight years of age it is impossible to remove more than 1 cm. of the tibia, or $1\frac{1}{2}$ cm. ($\frac{7}{12}$ of an inch) of the femur, without approaching dangerously to the epiphysial lines.

After puberty (e.g. in a youth of seventeen years) it is possible to remove $1\frac{1}{2}$ cm. of the tibia, and $2\frac{1}{2}$ cm. (1 inch) of the femur, without compromising the epiphysial lines.

The popliteal artery is so placed that it is in greater risk of being wounded when the tibia is sawn than when the lower part of the femur is being removed.

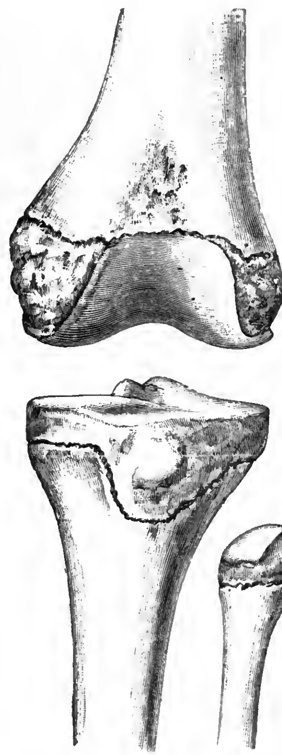

FIG. 482. — EPIPHYSES OF THE FEMUR, TIBIA, AND FIBULA.

1. **Operation by Curved Transverse Anterior Incision.** — Of the many methods that have been described and adopted, this is undoubtedly the most suitable.

Position.—The patient lies upon the back, with the limb close to the margin of the table. The lower part of the leg should project a little beyond the table, so that when the knee is bent at a right angle the foot may be able to rest, flat upon the sole, upon the end of the table.

The surgeon stands upon the side to be operated on. Some surgeons prefer to stand upon the left side of the limb in the case of either extremity, a position which is certainly more convenient for sawing. One assistant places himself opposite to the surgeon, and steadies the limb by the thigh. Another assistant near the foot of the table holds the leg, and manipulates it as required. A third assistant by the surgeon's side attends to the sponging, etc.

At the commencement of the operation the limb is held with the knee a little flexed. Later, the joint is bent at a right angle. It is essential that an Esmarch's tourniquet should be applied. Unless the part is rendered bloodless it is impossible to detect and remove all the tubercular membrane, etc.

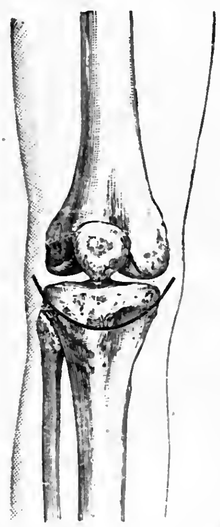

FIG. 483.—EXCISION OF THE KNEE.
The transverse curved incision.

(1) *The Skin-incision.*—A curved incision, convex downwards, is made across the front of the knee below the patella.

The incision commences and terminates at the posterior margin of one of the femoral condyles, while its lowest point in front corresponds with the insertion of the patellar ligament (Fig. 483). During the making of this wound the knee-joint is held a little flexed, and the skin and subcutaneous tissues are alone divided at the first sweep of the knife.

(2) *Dividing of the Ligaments.*—The knee is now flexed a little more, and with another sweep of the knife the anterior part of the capsule and the patellar ligament are cut through, and the joint opened below the knee-cap.

The patella, with its attached aponeurosis, is turned upwards, the joint is still more flexed, and the surgeon proceeds to divide in order the later and the two crucial ligaments.

(3) *Sawing of the Femur.*—The joint is now bent at a right angle, and the limb held firmly in that position, with the sole of the foot planted upon the table.

The femur is cleared with the knife at the future saw-line.

The bone is sawn from before backwards, and with regard to the plane of the section (Fig. 484) these two points must be observed :—

The plane of the saw-cut in the antero-posterior direction must be at right angles to the long axis of the shaft of the femur, and in the transverse direction it must be parallel to the plane of the free surface of the condyles.

During the sawing process the condyles may be grasped and steadied with lion forceps, although, if the limb be firmly held, this is not necessary. The femur rests upon the tibia. The tissues of the ham must be protected by means of an ivory

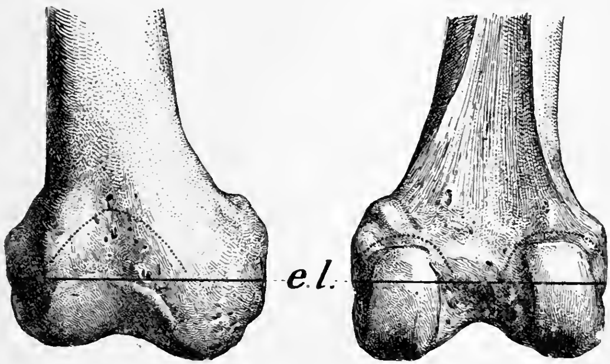

FIG. 484.—LINE FOR DIVISION OF THE FEMUR IN COMPLETE EXCISION OF THE KNEE-JOINT.
The surgeon should, if possible, not remove more than this with the saw.

spatula held behind the femoral condyles, or by a broad elastic or thin metal band.

(4) *Sawing of the Tibia.*—The upper end of the tibia is now held forwards, the foot is still pressed firmly against the table, the shaft of the bone is maintained in the vertical position, and in consequence the articular surface will be quite horizontal. The bone is cleared with the knife for the passage of the saw, and a thin slice is removed by sawing from before backwards, the saw being kept precisely parallel to the articular surface, and therefore at right angles to the shaft (Fig. 485). The popliteal tissues must be protected in the manner already described; and if the movements of the saw be slow and deliberate, there is no danger of wounding the structures of the ham.

The two bony surfaces should now be parallel, and should fit accurately when brought together.

(5) *Treatment of the Patella and Synovial Membrane.*—The most tedious part of the operation remains. The patella must be dealt with according to the practice of the individual surgeon. It may be removed, whether healthy or diseased, by dissecting it out, with the least possible disturbance of the surrounding tissues; or if entirely sound, it may be left. Or it may be steadied in a vertical position while its articular segment is removed with the saw in the form of a thin layer; or its tissue may be so scraped and cut away that nothing remains but the anterior layer of compact bone.

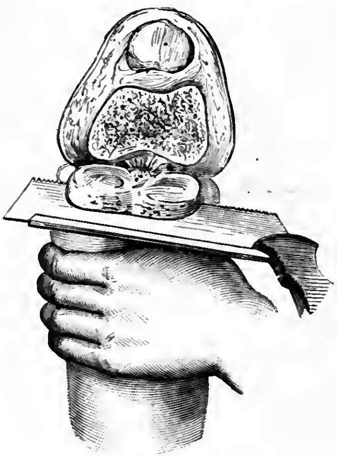

FIG. 485.—EXCISION OF THE KNEE: THE SAWING OF THE TIBIA.

With the knife and scissors, aided by the sharp spoon, the surgeon now proceeds to remove all the diseased synovial membrane which may remain. The pouch beneath the quadriceps tendon is opened up, and is carefully cleared out by means of the sharp spoon.

Any existing sinuses are opened up and scraped, and by one means or another a careful and determined attempt is made to rid the operation area of every trace of diseased tissue. The part is now well flushed with sterilised warm water, and carefully dried.

Nothing remains but to close the wound with sutures—silkworm gut being the best for the purpose—and to adjust the limb upon the splint which has been prepared for it.

The question of uniting the bony surfaces by means of wires or ivory pegs is considered afterwards (page 774).

A drainage-tube is introduced into the posterior angle of the wound on either side; or a single tube may be passed behind the bones, and be made to traverse the depths of the wound from one side to the other.

The sutures should not be introduced until after the limb has been fixed upon the splint, so that up to the last moment

the surgeon may be able to satisfy himself that the bones are in proper position.

The drainage-tube will be inserted before the limb is adjusted to the apparatus.

No blood-vessels of any importance are divided. The arteries actually severed will be branches of the articular arteries, of the anastomotica magna, and of the anterior tibial recurrent. Continued pressure with a dry sponge will be sufficient to check such bleeding as is usually met with.

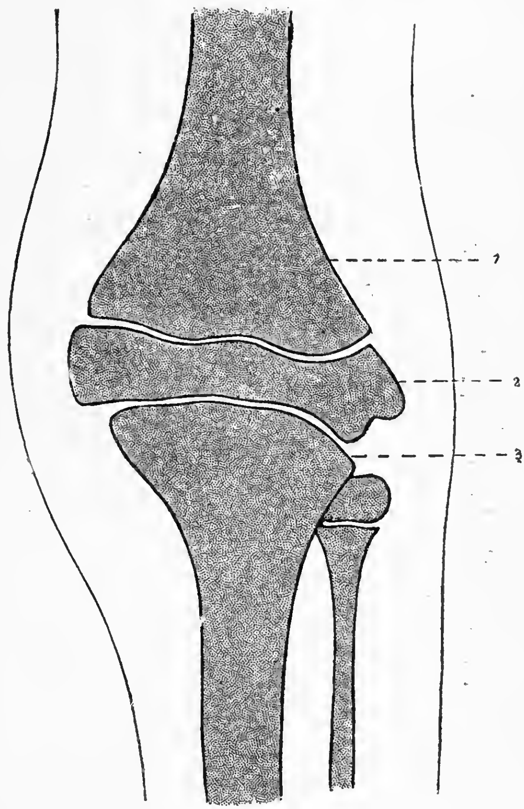

FIG. 486.—SKIAGRAPH OF A CASE OF EXCISION OF THE KNEE.

1, Shaft of femur; 2, Remains of femoral and tibial epiphyses fused into one; 3, Diaphyseal shaft of tibia.

Comment. — A well-padded straight back splint with a foot piece should be used. It should have been carefully selected beforehand for the individual case; if not, the surgeon will probably find that it is too short and does not fix the femur sufficiently. The upper end of the splint should reach almost to the gluteal fold.

It is a good plan to have the limb kept sloping strongly upwards on an inclined plane for twenty-four hours or so after the operation. This will prevent or check any oozing of blood.

The internal limit of the incision should not be carried

backwards beyond the point indicated, in case the internal saphenous vein and nerve be wounded.

The utmost care must be taken to respect the epiphysial lines of the femur and tibia in young subjects. If they are damaged, it will lead to a shortened, deformed, and possibly useless limb.

The femur and tibia should be sawn from before backwards. The best instrument is a wide-bladed thin saw with a movable back. In the hands of some surgeons a Butcher's saw appears to be more convenient. There is no real danger of wounding the popliteal vessels in sawing the tibia if reasonable care be exercised, and there is consequently no need to adopt the somewhat difficult manœuvre of sawing that bone from behind forwards.

The precise manner in which the femur is sawn is of primary importance. If the section be not made as directed, the bones may not come well together, and a subsequent displacement would be encouraged, while the best conditions are not provided for securing firm ankylosis. On the other hand, the limb may assume the deformed position of either knock-knee or bow-knee.

In adjusting the bones the two surfaces should be made to come accurately and evenly together, and in bringing them into position care must be taken not to pinch the relaxed posterior ligament between the hinder margins of the freshly-cut femur and tibia. The limb should be so disposed as to be absolutely straight, and the position of slight flexion advised by some is distinctly to be condemned. In the final scraping away of the diseased soft parts especial care must be taken fully to expose and evacuate the suprapatellar synovial pouch.

With regard to the fixing of the bones with metallic sutures or pegs, it must be observed that such a measure effects its object but feebly, that primary healing is apt to be hindered, that the subsequent removal of the wires or pegs may be difficult, and that the presence of these foreign bodies may excite some mischief in the bones.

If a really suitable, strong, and well-adjusted apparatus be used to fix the limb, the employment of the means just named becomes quite unnecessary.

2. **Other Methods of Excising the Knee.**—The many operations, with which the names of as many surgeons are associated differ but little from one another except in the matter of the skin incision.

(1) Moreau employed an **H**-shaped incision, which was accepted by many of the earlier operators, with certain more or less insignificant modifications.

One form of incision employed by Ollier reverts to this early method of dividing the skin (Fig. 487, B). Ollier attempts to carry out the excision as far as possible upon the subperiosteal plan; but the anatomy of the joint, and the conditions under which the operation is usually performed, do not lend themselves to this method, which is indeed distinctly unsuited to this part of the body. Even if carried out precisely upon the lines laid down by Ollier, it is still incomplete. An extensive arthrectomy is the nearest approach to a subperiosteal operation.

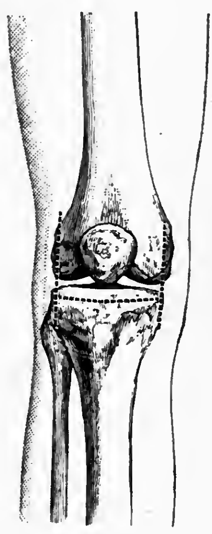

FIG. 487.—EXCISION OF THE KNEE.

Ollier's subperiosteal method.

(2) Longitudinal incisions are employed by some surgeons. The incision may be median, and the patella either turned aside or split vertically, and then united by suture after the operation is completed.

Langenbeck employs a vertical cut some five inches in length, which is situated upon the antero-internal aspect of the joint. The knife divides the vastus internus half-way between the inner edge of the patella and the internal condyle, and is arrested opposite to the inner tuberosity of the tibia.

The bones are dislocated inwards, and removed.

Jeffray, Sédillot, and William Knight Treves employed two vertical lateral incisions, dividing the bones by means of a chain-saw or a very narrow hand-saw.

Prof. Kocher advocates a vertical incision similar to Langenbeck's; its lower end curves forwards. The insertion of the ligamentum patellæ (the tubercle of the tibia) is reflected by a chisel, and subsequently sutured or pegged in place again.

The method by a longitudinal incision is difficult and tedious. A small space is provided, a good view of the interior of the joint cannot be obtained, the removal of all the diseased tissue is less surely

effected, and good drainage cannot be provided for unless a special drainage incision be made.

(3) Golding Bird preserved the patella, but sawed it through transversely to reach the joint, and after the excision united the two fragments of the bone together with sutures. Dr. Fenwick, of Montreal, saws both femur and tibia in a curved line, "so as to make them fit together more closely and accurately than they would do otherwise." There is nothing to recommend this method, while many very cogent arguments may be urged against it.

After-Treatment.—The after-treatment is of the utmost importance, is tedious, and is often surrounded with difficulties. There is a tendency to displacement, and notably to a displacement of the tibia backwards. If sound healing do not take place, the limb is worse than useless, and the flail-like limb that may result is of less service to the patient than a good artificial leg.

The limb must be put up perfectly straight—i.e. in the position of complete extension—and for the purpose of fixing it many surgeons employ plaster of Paris. The rigid dressing formed of this material is not entirely satisfactory. It may exercise an unequal pressure upon the parts, and may lead to œdema, etc. Discharge may find its way between the splint and the limb, the dressing is difficult to remove, and even when large "windows" are provided the inspection of the part can never be so complete as it should be.

Such a splint should be provided as will allow the bones to be kept in good position, will permit of a free inspection and examination of the wound, and will not interfere with dressing and drainage, should drainage be necessary.

It is well that the splint should be suspended.

Prof. Howard Marsh points out that "the plan of firmly bandaging the lower end of the femur to the back splint leads to great swelling about the wound, and materially retards repair. It is apt also to induce persistent venous oozing after the operation." To avoid these drawbacks, he employs Gant's splint. This simple splint, instead of binding the femur down to the level of the tibia, brings the tibia up to the level of the femur, and no tight bandaging is called for.

Not a few of the splints employed have the disadvantage of being complex, and difficult to adjust.

Dry dressings should be applied to the wound.

As soon as the wound has soundly healed, and union has begun between the bones, that is at the end of about a month, it is well to give up the splint and fix up the limb securely in a poroplastic or plaster-

of-Paris case. This should reach from the ankle to near the hip The patient can then leave his bed and after a time can walk about. This undoubtedly favours firm bony union. Some sort of leather or poroplastic support—strengthened by a band of steel posteriorly—should be worn long after union seems firm, as a precaution against deviation from bending. In children Mr. Jacobson advises the use of such a support for three years or more. In adults it may be at least twelve months before the bones are firmly knit together.

A thick-soled boot will be required to meet the inevitable shortening, which, however, in the best cases does not amount to more than about an inch.

CHAPTER VIII

EXCISION OF THE HIP

This operation implies the removal of merely the upper end of the femur, and the scraping away of any diseased tissue which may occupy the acetabulum. As in the case of the shoulder-joint, so here also the excision does not involve the whole joint and the entire articulating surfaces.

The value of the operation, the conditions under which it should be performed, and the character of the results obtained, have been, and still are, subjects upon which the most diverse opinions are held.

It may be assumed, in the first place, that excision of the hip is usually performed for chronic suppurative joint disease occurring in young subjects. In all but a quite small proportion of the cases the mischief is tuberculous.

The age between six and fourteen is considered to be the best for the operation, and few even of those who practise excision extensively would carry out this measure in patients over sixteen years of age. One or two surgeons have expressed the opinion that the operation should never be performed in patients under the age of ten.

Prof. Howard Marsh is much opposed to the operation ("Diseases of the Joints," 1886). He considers that the treatment by continued rest provides such admirable results (recovery with but slight lameness and but slight loss of movement in 70 per cent. of the cases, and a mortality of about 5 per cent.) that the conditions which would sanction excision are present exceedingly seldom. Even when suppuration has occurred, he would not place the mortality above 6 or 8 per cent.

He considers that operation in the early stage of the disease is unjustifiable, and that in very advanced disease the excision will be of doubtful benefit. Mr. Bowlby, from very large experience, is also wholly opposed to excision in children with tubercular hip disease.

Mr. Wright, on the other hand, is strongly in favour of the operation, and considers that it should be performed early—at least as soon as there is any evidence of external abscess ("Hip Disease in

Childhood"). Mr. Wright has performed excision in over one hundred cases. Prof. Koenig of Berlin has recorded probably the largest personal experience of this operation. Out of 566 cases of hip-joint disease he excised the femoral head in no less than 300.

The usefulness of the limb obtained after excision has also been the subject of considerable difference of opinion.

Into this very wide, complicated, and vexed question it is impossible here to enter. It is only necessary to point out that the position of this operation cannot yet be considered to be fully established, and it may be suggested that the truth will be found to be in a course midway between the two very adverse modes of practice to which allusion has just been made.

One thing certain is that the operation is performed with less and less frequency, and is becoming a quite rare measure.

The excisions at one time practised for ankylosis in a bad position have been replaced by osteotomy.

Excision of the hip was first suggested by Charles White, of Manchester, in 1709. It was first performed by Anthony White, of the Westminster Hospital, in 1818. The operation was carried out on a boy of fourteen to remedy the result of long-standing hip disease. Four inches of the femur were removed. A good recovery followed.

The operation was but seldom practised until the time of Sir William Fergusson, who did much to bring the measure into general use (*Med.-Chir. Trans.*, 1845).

Within recent times the operation has perhaps been somewhat too extensively and too indiscriminately practised; and after a reaction in the opposite direction of condemning the operation altogether has passed away, the true use and position of the excision will no doubt be established. Valuable help to the surgeon's decision may be obtained from radiography. By this may be ascertained the presence of a sequestrum, which in itself is a clear indication for operation.

Anatomical Points.—The hip-joint is deeply placed, and is surrounded by numerous muscles. In front are the psoas and iliacus; behind, the quadratus femoris, the obturator internus, the two gemelli, and the pyriformis; on the outer side are the gluteus medius and minimus and the rectus; and on the inner side are the pectineus and obturator externus.

The capsule of the joint is exceedingly strong, and forms indeed the strongest ligament in the body. The thickest parts of the capsule have received the names of the ilio-femoral, the ischio-femoral, and the pubo-femoral ligaments, and here the synovial sac often communicates with the bursa which lies beneath the psoas muscle at this

spot. The capsule is also weak where covered by the obturator muscles.

The upper border of the great trochanter is on a level with the centre of the hip-joint. A line (Nélaton's line) drawn from the anterior superior iliac spine to the most prominent part of the tuber ischii will cross the centre of the acetabulum and will hit the top of the great trochanter. The head of the femur lies close below Poupart's ligament and just to the outer side of its central point.

The position of the chief bursæ about the hip-joint should be borne in mind.

Ossification commences in the head of the femur ten months after birth, in the great trochanter in the fourth year, and in the lesser trochanter in the thirteenth year. The last-named process of bone joins the shaft at the age of eighteen, the great trochanter joins about eighteen and a half, and the head about the nineteenth year. The neck is ossified by an extension from the diaphysis, and this upper extremity of the shaft serves to separate the head from the two trochanters.

The acetabular element of the os innominatum ossifies in the sixth year, from one or more centres which appear in the **Y**-shaped cartilage.

The bone so produced joins with the ilium and the ischium at the age of fourteen, and with the os pubis at fifteen. The ossification of the acetabulum is completed at about the age of seventeen years.

The shortening which follows upon removal of the upper end of the femur in a young subject is much less than would be expected. Indeed, such diminution of length as follows would appear to be due rather to the actual loss of bone, to some possible displacement of the upper end of the femur, and to the general atrophy which is marked in the entire extremity. The principal increase in the femur is effected by the lower epiphysis. Little growth is accomplished by the upper. A main feature of the shortened limb after hip disease is certainly due to a general arrest of development in the entire limb.

The Operation.—There are several methods of approaching the head of the femur, but the one from the anterior aspect has several advantages over the others, especially as regards the fact that it involves division of no important muscles. For this reason we describe this method only.

Anterior Incision.—The incision employed is that advised by Dr. Hueter in 1878, and independently by Mr. R. W. Parker (*Clin. Soc. Trans.*, vol. xiii.). In this country it is often known as Barker's method, as Mr. A. E. Barker drew

attention to its merits in the *British Medical Journal* of Jan. 19th, 1889. Mr. Barker at one time practised it in cases of early disease of the joint, a course which has been endorsed by few, if any, surgeons.

The patient lies supine, with both thighs fully extended. The surgeon stands in every case on the right side of the patient; one assistant, facing him, holds the affected thigh, another stands beside and to the left of the operator.

The most precise and rigorous aseptic measures are carried out.

The incision commences on the front of the thigh, half an inch below the anterior spinous process of the ilium, and runs downwards and a little inwards for three inches. As the knife sinks into the limb it passes between the tensor vaginæ femoris and glutei muscles on the outside, and the sartorius and rectus on the inside, until it reaches the neck of the femur. This incision does not divide any muscle fibres or vessels or nerves of the slightest importance. It is unnecessary to carry the deeper part of the incision to the full extent of the external wound. If an abscess is opened up before the joint is reached, its contents are thoroughly flushed out with sterilised hot water, at a temperature of between 105° and 110°, before anything further is done. Mr. Barker's well-known flushing-gouge may be used for the purpose—though an ordinary strong Volkmann's scoop will answer equally well. The abscess having been cleared out by means of the rush of hot water, the neck of the femur is sawn across with a narrow saw in the direction of the external wound. The diseased head can then be lifted out by means of a sequestrum forceps, aided by an elevator. By the time the head of the bone has been got out, the whole cavity is comparatively clean.

FIG. 488.—EXCISION OF THE HIP: LÜCKE'S ANTERIOR INCISION.

Now begins the search for further disease. This can usually

be easily estimated by the left forefinger, with which the acetabulum is first examined, and then all the other parts of the joint-cavity. Wherever diseased material is felt, it is cut away by the flushing-gouge or scoop, the hot water carrying away the *débris* as fast as it is produced, and with it all blood, while at the same time it arrests bleeding from the fresh-cut surfaces. When every part of the field of operation has been gouged and scraped clean of all tuberculous material, and the water runs away clear, the cavity is dried out with sterilised sponges, one or two of which are left in it until all the stitches are placed in position. These should dip deeply and be placed close together. Just before they are tied the sponges are removed, and with them the last traces of moisture. The anterior wound is perhaps not well adapted for drainage, and if preferred a tube may be passed through an opening made through the muscles at the back of the joint. Mr. Barker, however, does not consider this necessary. The whole joint is covered with aseptic gauze so adjusted that evenly graduated pressure is brought to bear upon every aspect of the field of operation, while the limb is held well abducted. If the wool be now firmly compressed with a spica bandage, the walls of the whole clean-scraped cavity are brought into contact, and the remainder of the neck of the femur is thrust into the acetabulum and secured there.

When all this has been done, although there remains potentially a cavity, there is actually nothing of the kind, for all the surfaces have been brought into apposition. And then, assuming that perfect asepsis has been observed, all these surfaces ought to unite with a minimum of exudation. After the operation the patient is at once placed upon a Thomas's double splint or on a box-splint, interrupted opposite the region operated upon.

After-Treatment.—Dry dressings should be employed, and if primary healing is aimed at a fair degree of pressure should be brought to bear upon the part.

The limb must be kept at perfect rest, and in the position of extension.

Of the many splints advised, the most convenient is either a Thomas's double splint or a so-called box-splint, already mentioned.

The child is held firmly, and can be lifted up and turned over

without any movement being produced at the hip-joint. These cases require much care in the nursing. The average period involved in the after-treatment will probably be not much less than six months in any case in which the disease was advanced at the time of the operation.

Results.—The mortality after excision of the hip was, before the days of antiseptics, very high. Culbertson gives the mortality after operations for disease as 45·1 per cent. The mortality of the operation at the present day is, in properly selected cases, no higher, probably, than 5 per cent. Mr. Wright has given a list of over one hundred cases of excision, with only three deaths that may be ascribed to the actual operation.

The functional result after a successful excision is usually satisfactory. Ankylosis very seldom follows. The limb is frequently atrophied, and some shortening is inevitable.

A flail-like condition of the limb, with perhaps a marked degree of shortening, will depend either upon the removal of an exceptionally large amount of bone, or upon allowing the patient to move the limb and bear weight upon it too early.

It must be acknowledged, however, that, taking a large number of average cases, the results which follow the treatment by rest are superior in most, if not all, respects to such as follow the treatment by excision.

CHAPTER IX

ARTHRECTOMY, OR ERASION OF A JOINT

THIS operation consists in fully exposing the interior of the joint, and in removing the whole of the diseased synovial membrane and ligamentous tissue, together with such patches of cartilage or bone as may be the seat of quite limited disease.

This removal is accomplished by means of the scalpel, the scissors, the sharp spoon, or the gouge. The measure aims at removing *all* the diseased tissue, and diseased tissue *only*.

In principle it represents the application to the interior of the joint of a method of dealing with certain morbid conditions, known as the method by scraping, which has been developed within the last few years, and which the introduction of antiseptic measures has allowed to be applied to extensive and important districts.

The method is in reality a by no means modern procedure revived and improved. The operation of arthrectomy, as it is now known, would appear to have been of gradual and almost unconscious development. Surgeons began cautiously to apply to chronically inflamed joints, and perhaps first of all to the sinuses about them, a method of treatment they had already found successful in like conditions elsewhere.

It would appear that in 1881 Mr. Cross, of Bristol, advised the carrying out of the measure now known as arthrectomy, and he gave then an illustrative case.

Since that time the procedure has rapidly developed.

To Mr. G. A. Wright is due the credit of being among the first to publish any detailed account of the procedure. He has, moreover, done much to elaborate and perfect the operation, to give it a definite position among surgical methods, and to establish its value and its application as a mode of treatment.

His first case was published in the *Lancet* for 1881. A fuller communication was made before the British Medical Association in 1883, and in 1885 a series of sixteen cases was published in the *Medical Chronicle*.

The operation is chiefly, if not entirely, applicable to the knee-joint. It has been carried out in the elbow and ankle, but, as Mr.

Wright observes (*Lancet*, 1888), " in joints with complex bony surfaces, and in joints where free mobility is an important element, also in joints where the primary and main lesion is bony, the operation can never have any great measure of success."

Arthrectomy forms an essential part of all excisions for chronic joint disease, it being necessary that all traces of tuberculous tissue should be removed by scraping or dissection after the articular parts of the bones have been sawn off.

The measure may be regarded as a conservative one, and is in the opinion of some applicable to relatively early cases. It is unsuited to examples of advanced disease, except as an accessory measure. It is not adapted to cases attended by much suppuration. It is especially applicable to children.

Instruments required.—Excision knife; scalpels; scissors, both straight and curved on the flat; sharp spoons of various sizes and shapes; gouges; toothed forceps; Wells' forceps; retractors; irrigator for using warm sterile water; a saline lotion.

The Operation (*as applied to the knee-joint*).—The use of Esmarch's tourniquet is strongly advised.

The patient lies upon the back, with the knee a little flexed and the sole of the foot resting flat upon the table.

The surgeon stands to the outer side of the limb, or he may find it convenient to place himself upon the right side in the case of either limb. An assistant placed at the end of the table, and another opposite to the surgeon, hold the limb securely. A third helper by the surgeon's side attends to the sponging, etc.

A curved transverse incision is made across the front of the knee-joint, as in performing excision (page 770). The incision may be commenced at the posterior part of one condyle of the femur, be carried across the front of the limb over the middle of the patellar ligament, and end at the posterior part of the other condyle. The patellar ligament is divided, the joint fully opened, and the skin flap with the patella turned up upon the thigh. The knee is now flexed at a right angle, and the interior of the joint well exposed.

The surgeon then proceeds to remove all the diseased synovial membrane, and such of the extrasynovial tissue as is also involved. The latter would include all softened ligamentous tissue. As much as possible should be removed in a continuous layer by means of the scalpel and forceps, or the scissors and

forceps. The semilunar cartilages are removed. The lateral ligaments should be spared if possible, as their removal greatly weakens the joint.

The crucial ligaments should be spared whenever possible. They must be stripped, however, of every trace of diseased membrane, must be most carefully inspected, and subjected to a vigorous scraping over all suspicious parts. The articular surface of the posterior ligament must be exposed, and also freed from all degenerate and pulpy tissue.

This ligament should not be divided, nor, if it can be helped, should any opening be made into the popliteal space.

When the interarticular district has been completed, and the work of the scalpel or scissors followed up by the sharp spoon, until no trace of disease has been left behind, the surgeon turns to the anterior flap.

All the synovial membrane which covers this flap should be dissected off, the subcrural bursa must be fully opened up, and its lining membrane treated in the same way. Every nook and cranny must be patiently explored, and every fragment of tuberculous tissue removed. The complete removal of every scrap of diseased tissue from the subcrural bursa is very important. Here again the erasion must be completed with the sharp spoon, and every neglected point and corner subjected to a careful and complete scraping. Finally, the cartilages and bones must be well examined. Patches of softened or eroded cartilage may be sliced off, and points of caries in the bones freely removed with a gouge.

The bleeding is arrested by the pressure of a sponge, which is maintained as long as possible, and by means of pressure forceps. Ligatures are but seldom required.

The articulation is then thoroughly washed out with sterilised warm water, well sponged, and dried.

The limb is placed upon the splint prepared for it, and, the patellar ligament having been united by kangaroo tendon, the wound is closed with silkworm gut.

Drainage-tubes should be avoided whenever possible, and in a large percentage of the cases they can be dispensed with, provided that the margins of the wound are not too closely approximated.

If drains be considered necessary, one should be inserted into the posterior angle of the wound on each side.

The dressing should be ample and firmly applied.

After-Treatment.—This closely follows the treatment observed after excision of the knee.

The limb should be supported by a back splint, which extends from the fold of the nates to beyond the heel, and terminates in a rectangular footpiece.

If the case has been a really favourable one, passive motion should be resorted to as soon as the wound is healed, and every effort made to ensure free motion.

On the other hand, there is a danger, if the ligaments have been interfered with during the operation, of the lateral mobility becoming too free, and the limb unsteady. In such a case a poroplastic support should be worn for a considerable time. Every case must be followed up by the surgeon during the next few years. A considerable proportion result in a second operation—complete excision, or even occasionally amputation.

PART VIII.—OPERATIONS ON TENDONS, INCLUDING THE DIVISION OF CONTRACTED MUSCLES, LIGAMENTS, AND FASCIÆ

CHAPTER I

TENOTOMY

GENERAL CONSIDERATIONS

1. **The Subcutaneous Method.**—The object of this method is to divide the tendon with the least disturbance of the surrounding parts and with the smallest possible division of the skin. Air is not admitted to the deep wound ; the risk of sepsis is thus minimised, and the surface puncture heals readily and surely. Before the introduction of the antiseptic method of treating wounds the subcutaneous operation was all-essential. It is now much less important. At the present time it need only be carried out when convenient. It must be remembered that in the subcutaneous operation the surgeon is cutting a little in the dark, and in dividing such tendons as that of the tibialis posticus and the sterno-mastoid considerable damage has been inflicted by the movements of the invisible blade beneath the skin. This more especially applies to fat infants and to examples of extreme deformity.

In any case in which the tendon is not manifest or is difficult to discover, or in which its relations with nerves and vessels are complex and intimate, it is better to adopt the open method of the older surgeons, and to expose the area of the operation by a free incision.

There is no need to draw the skin aside before making the puncture in order that the wound in the skin may not correspond to the wound of the deeper parts when the operation is complete. Such a method is embarrassing, and adds a needless difficulty to a simple procedure. The skin, moreover, may be unnecessarily cut by the knife against which it is strained.

It must not be assumed that because the subcutaneous method is employed, no care need be taken to ensure an aseptic environment for the little operation.

The parts should be well scrubbed with an alcoholic solution of biniodide of mercury or of carbolic acid; the tenotomes should be sterilised by holding them in boiling water and then in absolute alcohol.

2. **Use of the Tenotome.**—The tendon or band of fascia to be divided is usually unduly prominent, or can be readily made distinct. The tendon should, if possible, be so cut as to avoid opening a synovial sheath.

The tenotome should be lightly held, as one would hold a pen. The sharp-pointed instrument is carefully introduced close to the tendon, and makes a way for the blunt-pointed instrument. It is essential that it should make an ample passage for the blunt-pointed tenotome, and therefore the cutting point may need to be moved freely to and fro in the region of the tendon. If this be not done, the blunt tenotome may have to be forced to its destination through tissues that have been merely punctured.

The sharp tenotome is withdrawn, and the blunt instrument introduced with the blade "flat"—that is, in a line with the line of the skin-wound.

The instrument should throughout be kept close to the tendon or band to be divided, and care must be taken to avoid damage to adjacent vessels or nerves. The breaking of the point of the tenotome against the bone is a not very infrequent accident in the hands of beginners.

As the tenotomes are being introduced the tendon should be only stretched to such an extent as is necessary to render its position distinct. It needs to be stretched to its utmost when its fibres are being divided, but this tension may be a little relaxed as the last strands are being cut. The tendon is divided with a sawing movement; it cuts with a creaking sound or sensation, and yields finally with a snap. A common source of failure after this operation is an incomplete division of the tendon.

The left forefinger should be kept upon the skin at the site of the operation, in order that the movements of the tenotomes beneath the integument may be followed and guarded.

It is not usually desirable to do the whole operation with the sharp tenotome only. In dealing with certain bands of contracted fascia, and some few tendons, the one instrument may be employed. But in most cases, especially when the tendon is surrounded by tissues of importance, the two instruments should be made use of—the sharp-pointed tenotome to divide the skin and the fascia about the tendon, and the blunt-pointed instrument to sever the tendon itself.

This operation *à deux temps* involves a little more time and is a little less brilliant, but it is safer and more satisfactory.

3. **After-Treatment.**—The operation is practically bloodless, and the only dressing needed is a pledget of sterilised gauze or wool. In forty-eight hours the little puncture may be considered to be healed.

The only factor in the after-treatment which has been the subject of much difference of opinion has to do with the adjustment of the limb after the tenotomy.

The discussion upon this subject has been practically limited to the treatment of cases of club-foot, and the question has been—Should the foot be immediately restored to its normal position after tenotomy, or should it be put up for a while in the deformed or original position?

The latter may be called the slow method, and was formerly employed as a rule because of the belief that with immediate rectification a wide gap would be left between the tendon-ends which might not be filled at all.

On the other hand, the immediate method, fixing the part in as correct a position as possible immediately the tendons and fasciæ are divided, has come more and more into use, and with few exceptions may be regarded as quite safe.

It has been clearly shown that in the *immediate* method there is no failure in the uniting material which joins the ends of the divided tendon, nor has the uniting band remained weak or elongated. The possibility of this occurrence has been the main argument in favour of the *slow* method.

The above remarks refer for the most part to infants and children. In dealing with the largest tendons—such as the tendo Achillis in adults—it is desirable still to adhere to the slow method, to allow the limb to remain for some days or a week in the deformed attitude, and then gradually to correct the false position. In not a few instances in which the limb has been adjusted in what may be termed the normal position, after the accidental rupture or division of a large tendon in an adult, the union between the separated ends has been feeble and inefficient.

4. **Instruments used.**—Sharp- and blunt-pointed tenotomes with straight blades are the only instruments needed. These knives must vary, both in size and strength, according to the proportions of the structure requiring division. There should be a mark upon the handle to indicate the position of the cutting edge when the blade is out of view.

PARTICULAR OPERATIONS

Tibialis Anticus Tendon.—This tendon descends through the innermost sheath of the annular ligament, and, crossing the ankle-joint, astragalus, scaphoid, and internal cuneiform bones, is inserted into the inner side of the last-named bone and the base of the first metatarsal bone. The synovial sheath which accompanies it extends upwards for some distance above the level of the malleoli. A small bursa lies beneath the tendon as it crosses the cuneiform bone.

This tendon is usually divided as it is crossing the scaphoid bone, and consequently about one inch above its insertion. At this point it should be free of its synovial sheath. The dorsalis pedis vessels lie to the outer side, with the extensor proprius pollicis tendon intervening.

In cases of congenital club-foot the tendon is displaced inwards, and is nearer to the malleolus. It is readily made prominent.

Operation.—The surgeon stands on the outer side of the limb in the case of either tendon. The assistant, who takes his place opposite to him, grasps the foot with one hand and the leg with the other. The foot is held in the position of extension and abduction, and the tendon is defined. The sharp tenotome is then entered vertically upon the outer side of the tendon and is pushed downwards until it has reached a point below the level of the tendon. The operator's left forefinger is kept over the skin upon the plantar side of the tendon, as a guard upon the instrument. The tendon is put on the stretch. The sharp tenotome is withdrawn, and the blunt-pointed one inserted in its place. After it has reached the depth acquired by the first instrument (whose track it exactly follows) the foot is relaxed, and the blunt point is pushed horizontally beneath the tendon, and may be felt on its plantar side. The tendon is once more put upon the stretch, and is divided by cutting upwards towards the skin. The left forefinger lies upon the skin over the edge of the knife, and forms a certain check to its movement. The surgeon cuts, indeed, upon the left finger, the skin intervening.

Tibialis Posticus Tendon.—The tendon becomes free of muscular fibres about the level of the tibio-fibular articulation. It grooves the back of the inner malleolus, running in the innermost compartment of the internal annular ligament. Behind the malleolus it is invested with a synovial sheath. The flexor longus digitorum tendon lies next to it (to its outer side), and is provided with a separate synovial sheath. Externally to this latter tendon run the posterior tibial vessels.

The tendon is usually divided above the point of commencement of its synovial sheath, i.e. about the level of the base of the malleolus,

and therefore above the inner annular ligament. The tendon is here easily approached, and is at some distance from the blood-vessels.

Operation.—The surgeon stands to the outer side of the limb in the case of either tendon. The assistant faces him, and grasps the foot with one hand and the leg with the other.

The position of the tendon is made out, and the foot is held a little extended and abducted, and is so turned as to lie upon its outer side.

The surgeon seeks for that point on the inner surface of the tibia where the malleolus joins the shaft of the bone. He reaches this point by following the posterior margin of the malleolus. The spot in question will be about a finger's-breadth above the tip of the malleolus in the infant, and about one and a half to two inches above that process in the adult. It is really on the shaft, and is above what would be called anatomically the base of the malleolus.

The surgeon fixes his left thumb-nail upon the margin of the bone, and enters the sharp tenotome vertically between the tibia and the tendon, using the nail as a guide. The instrument should be kept as near as possible to the bone. If properly inserted it will remain, as Mr. Heath has pointed out, fixed, without any support of the hand. The tendon should not be too tightly stretched at this stage of the operation.

The fascia about the tendon should be freely divided by moving the point of the instrument to and fro, but without enlarging the skin-wound. Unless this be done, a proper way may not be made for the blunt-pointed instrument.

As the sharp tenotome is withdrawn the blunt one is introduced —the edge is turned towards the tendon, the tendon is put upon the stretch, and is divided by cutting from the bone. The left forefinger, placed over the site of the tendon, forms a guide and a guard. The tendon of the flexor longus digitorum is usually cut at the same time, and is often divided unconsciously.

The assistant should judiciously relax the strain upon the tendon as its fibres are divided.

It is obvious that if little care be taken the knife may cut through both the tendons, as through tightly drawn cords, and may wound the main artery beyond.

If the blood-vessels should be divided, well-adjusted pressure must be at once applied to the spot.

Singularly little trouble appears to have supervened in examples of this accident.

The position of the tendon may be difficult to make out in a case of talipes varus in an infant, and in connection with this point the

following observations by Dr. Little may be quoted: "When the surgeon cannot feel the tendon, it is practically quite sufficient to make out the inner edge of the tibia, about a finger's-breadth above the lower end of the inner malleolus; or, should there be any difficulty in defining this ridge of bone in consequence of the fatness of the limb, the careful insertion of the knife exactly midway between the anterior and posterior borders of the leg, on its inner aspect, will be an exact guide to the position of the tendon, not forgetting, as anatomy teaches us, that an incision made a little in front of this line might wound the internal saphenous vein and nerve, and if made behind would run the risk of dividing the flexor communis digitorum, instead of the tibialis posticus; or the knife might even pass posterior to the former tendon, and, if carried deep enough, might wound the artery and nerve without touching any tendon whatever."

Plantar Fascia, Muscles, and Ligaments of the Sole of the Foot.—These operations are concerned principally with cases of congenital talipes varus, and notably with such examples as are associated with considerable incurving of the sole. In the practice of some surgeons these plantar operations constitute the sole operative treatment of club-foot, if exception be made of tenotomy of the tendo Achillis.

The plantar fascia consists of a central and of two lateral portions. The central part—which was originally the plantar portion of the plantaris tendon—is the segment dealt with. Its great density is well known. It splits up into slips for the toes in front, while behind it becomes much narrowed and is attached to the inner tubercle of the os calcis.

It is closely connected with the flexor brevis digitorum muscle, which it covers. The ultimate fibres of this fascia are intimately associated with the skin.

Simple Division of the Plantar Fascia.—The sole of the foot is well exposed, and the limb is firmly held by an assistant. The resisting bands of the plantar fascia are made out by putting the parts upon the stretch. The part usually divided will be a little in front of the attachment of the fascia to the os calcis, or close to the transverse markings near the heel, which are conspicuous in severe talipes varus (Fig. 489).

A very fine, narrow, and short-bladed tenotome is employed, and is introduced between the fascia and the skin. The edge having been turned towards the resisting band, it is divided by cutting towards the depth of the sole, i.e. away from the skin.

The depth to which the cutting is continued must depend upon the thickness of the contracted tissue.

The surgeon would naturally avoid points where the fascia has become closely attached to the skin.

As a rule the contracted tissue will need to be severed at several points, and these multiple punctures are more efficacious than one single incision.

Parker's Operation: Syndesmotomy.—In cases of congenital talipes varus in children, Mr. R. W. Parker is disposed to attach much more importance to the division of ligaments and the plantar fascia than to pure tenotomy. "With the exception of the tendo Achillis," he writes, "I think tenotomy in club-foot might be almost abandoned as a separate and independent operation. The two other tendons most frequently cut are the tibialis, anterior and posterior. I believe, if it is necessary to divide them, that it should be done simultaneously with the ligaments with which they are closely associated; and this is most advantageously done at or near their insertions, where they spread out as fibrous expansions closely blended with the capsular ligaments connecting the head of the astragalus with the scaphoid, the scaphoid with the internal cuneiform, and this latter with the base of the first metatarsal bone, all these joints being much approximated by the incurvation of the inner border of the foot." This ligamentous tissue Mr. Parker calls the astragalo-scaphoid capsule, and he endeavours to combine a division of it with simultaneous division of the two tibial tendons. He terms the operation "syndesmotomy."

FIG. 489.—SOLE OF THE FOOT IN TALIPES VARUS, TO SHOW THE CREASES ON THE SKIN. (*Modified from R. W. Parker.*)

The site chosen for this section of combined ligaments and tendons is a spot a little below and in front of the tip of the inner malleolus, over the site of the astragalo-scaphoid joint, and in the situation of the transverse mark near the heel which is to be observed in severe talipes (Fig. 489). Two tenotomes are needed—an ordinary sharp-pointed tenotome, and a curved one of sickle shape with a cutting edge about half an inch in length.

The Operation.—The foot is so placed as fully to expose its inner border, and is firmly held; the position of the tendons and the arteries is made out as far as is possible.

At the spot above mentioned the sharp tenotome is entered. The point of entry should be in front of the bifurcation of the posterior tibial artery, and behind the posterior tibial tendon. The knife is pushed forwards and outwards under the skin until a spot on the dorsum is reached just internal to the anterior tibial artery The sharp instrument, which has made a track merely, is withdrawn. The curved tenotome is now inserted flatwise under the skin, and follows the subcutaneous course already made until its point can be felt over the tibialis anticus tendon. The edge is turned towards the tendon, and is made to cut to the bone. It severs the tendon, and, as it is withdrawn, is made in like manner to cut the dense ligamentous tissue already described. Just as it is being withdrawn it is made to sever the tendon of the tibialis posticus.

During the introduction of the instruments the foot is relaxed. While the tissues are being cut, it is put upon the stretch, and the yielding of the divided ligaments and tendons is made very evident.

Although the internal saphenous vein must lie across the incision, the bleeding is usually quite insignificant.

This operation has been extensively adopted, and has been attended with a considerable degree of success. Now that the treatment of wounds is conducted upon precise and successful principles, there is no reason why the subcutaneous method should be adhered to in this or allied operations.

The part to be severed might be exposed by turning up a small flap of skin, which could be replaced and secured by sutures after the division had been completed.

Tendo Achillis.—This very powerful tendon measures in the adult some four and a half inches in length, three-quarters of an inch in breadth, and a quarter of an inch in thickness. It is best divided at its narrowest part, i.e. about one inch above its insertion.

Operation.—The patient may lie upon the back, with the body a little rolled over towards the affected side. The foot is so turned as to lie entirely upon its outer side, and a small cushion placed beneath the lower part of the leg will carry the heel off the table.

The surgeon stands to the outer side of the limb, in the case of both the right and the left foot. An assistant standing by his side holds the foot. Another assistant may steady the leg. The tendon, having been defined, is rendered a little tense, but is not fully stretched. The sharp tenotome is entered vertically at the inner margin of the tendon, and is pushed downwards—in the present position of the foot—until it has reached the outer side of the tendon, where its point can be indistinctly felt. The sharp-pointed instrument is now replaced

by the blunt, which follows the track already made until its point can in turn be detected through the skin. The instrument must be kept very close to the tendon. The tendon is now put well upon the stretch, and, the cutting edge having been turned towards the surface, the tense cord is divided with a sawing movement, the left forefinger resting upon the skin over the site of the operation.

The divided ends separate with a snap, and unless care be taken just at the time when the tendon gives way, the integuments covering it may be divided by the suddenly liberated knife.

The short saphenous vein lies very near, and usually just anteriorly to, the outer margin of the tendon. The nerve which accompanies it is, as a rule, anterior to the vein, at a point one inch above the heel. The only structure in near relation to the inner border of the tendon is the unimportant calcaneo-plantar nerve.

Nothing but the grossest clumsiness could endanger the posterior tibial vessels.

The beginner is apt to fall into two errors. In the first place, he does not push the knife far enough towards the outer side, and as a result leaves the fibres most external to the tendon undivided; or, on the other hand, in his anxiety to keep close to the tendon he may thrust the sharp instrument through its deeper fibres, which at the completion of the operation are left uncut.

Some surgeons let the patient lie upon the face, with the foot overhanging the end of the table. They sit to operate, and, having introduced the tenotome upon either the inner or the outer side, cut upwards.

Hamstring Tendons.—The biceps tendon can be very readily felt upon the outer side of the popliteal space. Just behind it, and along its inner border, lies the peroneal nerve, which can be easily defined and rolled under the finger.

Of the semitendinosus and semimembranosus, the former tendon is the nearer to the middle line of the space, is more superficial, more distinct, and more cord-like. The latter tendon is the most deeply placed of the three hamstrings, and is of large size.

These tendons are most conveniently severed just above the line of the knee-joint, and on a level with the most prominent part of the condyles of the femur.

Biceps.—The patient should lie as far as possible upon the face, so that the popliteal space may be well exposed.

The surgeon may stand upon the inner side of the limb in the case of either the right or the left tendon. If he place himself to the outer side of the extremity, he will face the patient when dealing

with the left leg, and have his back to the patient when dealing with the right. The leg is steadied by an assistant.

In the conditions for which this operation is usually performed the contracted biceps tendon is drawn away from the nerve, and a wider interval than the normal separates the two structures. The safest plan, however, unless the nerve can be plainly felt through the skin, is to make a small incision, so as clearly to expose both nerve and tendon. The nerve being then held aside, the tendon is divided.

Both in the class-room and in practice we have seen a prominent and cord-like ilio-tibial band divided in the place of the biceps. In some thin and muscular subjects the lower portion of this fascial band may feel very tendon-like. Numerous contracted bands of fascia may come into view after tenotomy of the biceps for contracted knee. Some may need division.

There are few more disastrous accidents that can befall a surgeon than to divide the external popliteal nerve by mistake. It has happened many times, and we therefore emphasise again the importance of operating by the open method. With the nerve or tendon clearly exposed it is impossible to mistake one for the other.

Semitendinosus and **Semimembranosus.**—These tendons are most conveniently divided exactly opposite the spot selected for tenotomy of the biceps. The subcutaneous method will probably be preferred for their division, as no other important structure lies close to them; but there is no harm in exposing them by open incision.

The tenotome is introduced upon the outer side of the tendon, and is passed beneath it. The steps of the little operation need not be further described.

In one case Mr. Jacobson met with "most profuse" hæmorrhage in dividing the semimembranosus tendon in a girl of sixteen. He considered that the bleeding—which was checked by pressure—proceeded from the superior internal articular artery.

Dupuytren's Contraction.—The exact anatomy of the palmar fascia should be borne in mind, and especially the manner in which the digital processes of the fascia are disposed of, and the connections of the ultimate slips of the fascia with the integument of the fingers. It will be remembered that each division of the palmar fascia sends five slips: a central one to the sheath of the flexor tendons, one on either side to the skin at the cleft of the fingers, one to the superficial transverse ligament on either side, and one to the deep transverse ligament.

The pathology of Dupuytren's contraction need not here be dwelt

upon. It is for the relief of this condition that division of the palmar fascia is usually practised.

There are two methods of dealing with the contracted bands—the subcutaneous method and the open method. They are illustrated by the two operations now to be described.

1. *The Subcutaneous Operation.*—This consists in the division of the bands of fascia by the subcutaneous method, the sections being made at many points.

The fingers usually concerned in the contraction are the ring and little fingers.

A very fine and narrow tenotome is employed, which is introduced between the skin and the fascia, and is made to divide the band by cutting towards the depths of the palm, i.e. from the skin. The points selected for the operation are spots where the skin of the palm is free from attachment to the fascia. The knife is introduced at right angles to the line of the contracted band, and the bent fingers are put well upon the stretch when the section is being made.

Care must be taken not to dip the point of the tenotome into the deeper parts of the palm, and to divide the fascia and the fascia only The situation of the palmar arteries must, of course, be regarded.

Multiple punctures are needed. In an ordinary case—in which two fingers are involved—from six to nine punctures will usually be required.

These punctures concern the palmar bands, and it is easy, by dividing them, to overcome the flexion of the metacarpo-phalangeal joints. The contraction that may remain in the fingers, and that will be limited to the first interphalangeal joint, is not so easily corrected. It may be relieved by minute subcutaneous divisions of the fascia, carried out with great care in the region of the web. It is needless to say that with the fascial bands in this position the digital arteries and nerves are closely associated.

The attempt to overcome at once all deformity of the finger should not be pressed too far, but Adams's splint, with rack-and-pinion movements opposite the metacarpo-phalangeal and interphalangeal joints, should be applied, and the deformity be gradually overcome.

In any case a splint must be worn for several weeks. It is most important that the hand should not be allowed to stiffen from prolonged splinting. Only the fingers operated on should be fixed on the splint, and these should be given free play daily and well exercised.

This operation has afforded fair results, but it has been followed by a tendency to relapse, and, so far as our own experience goes, is

neither so successful nor in any way so sure as the treatment by the open method about to be described.

2. *Open Excision of the Contracted Bands* (Fig. 490).—The patient's hand must be sedulously cleaned with alcoholic solution of carbolic acid, etc., special attention being paid to the deep furrows caused by the contraction, in which dirt is apt to lie concealed. An Esmarch's tourniquet is convenient, and should be applied above the wrist. The hand being held by an assistant with the palm upwards and the fingers extended as far as possible, the surgeon makes a longitudinal incision directly over the main bands of fascia, and if necessary adds two short transverse cuts at either end. The skin is carefully reflected on either side, it being very easy to buttonhole it. The fascial band projects forward from the digital vessels and nerves, but it is necessary to avoid dividing these at the same time as the fascia. The band of the latter, having been cut through at the upper end of the incision, where it is a single tough cord, is then drawn out, and, with its various prolongations, again divided below. It is at this point that the digital vessels and nerves are in most danger. From one to two inches of the fascial band is removed, and the more thoroughly its divisions are dissected out the better will be the result. Indeed, it is well to dissect away all fascial tissue exposed which feels distinctly hard to the touch. If both ring and little fingers require to be operated on, it is better to turn back a longitudinal flap. After the tourniquet has been removed and bleeding stopped, the wounds are sewn up with fine silkworm gut. The incisions are apt to gape a little, and sutures should not be applied where they cause too much tension.

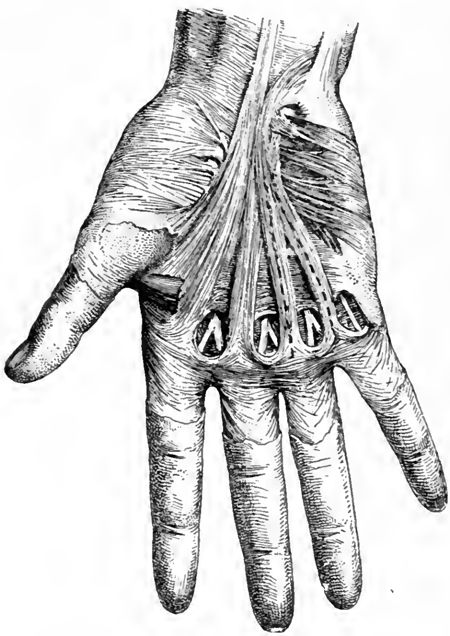

FIG. 490.—DISSECTION OF PALMAR FASCIA.

The two inner bands are the ones concerned in Dupuytren's contraction. The dotted lines over these indicate the incisions for their removal.

The fingers are put up on a splint in the extended position. The wounds will probably be healed in a week, but before this time the phalangeal joints should be flexed every day so as to prevent their becoming stiff.

Comment.—Of the two operations, the latter is no doubt a little more severe. It carries with it, however, only such slight risks as at the present day attend an open wound. The healing of the wound may be slow. There may be some swelling of the hand, and some pain. These are perhaps the main arguments against the measure. On the other hand, there are advantages attending an open wound. The surgeon does not cut in the dark, the operation area is well exposed, and not only can the contracted bands be divided with ease and certainty, but they are entirely removed. The skin, moreover, is very freely liberated over the whole of the affected district. The after-treatment is comparatively simple and of short duration. The results in my experience have been satisfactory, so long as asepsis has been secured and the fingers are not allowed to stiffen. Undoubtedly there is some drawback in the presence of scars on the palmar aspect of the hand.

In the subcutaneous operation the actual operative measure is certainly slight, and the wound made may be practically disregarded. The *after-treatment* is, however, tedious. The principal importance attaches to the use of the splint, to "gradual, quiet, and persevering extension," continued so long as to lead to atrophy of the divided fascial bands. The adhesions of the contracted fascia to the skin are left untouched. The after-treatment is such that the procedure is but indifferently suited to hospital practice; and although admirable results have been claimed for the operation, still many examples of relapse are forthcoming.

Division of the Sterno-Mastoid Muscle.—This muscle, or a portion of it, is divided just above its origin in certain cases of wry-neck. Sometimes division of the sternal tendon of the muscle suffices.

The tenotomy is best carried out about one-fourth of an inch above the upper border of the clavicle and sternum.

The sterno-mastoid is in this situation covered by the cervical fascia, and is crossed by the suprasternal nerve. The anterior jugular vein passes behind it, just above the clavicle, and is in danger of being wounded. This vein is, moreover, subject to considerable variation. The external jugular vein is in close relation with the posterior or outer border of the muscle.

To obtain the best result in operating for wry-neck it is essential

to divide not only the muscle, but also its contracted sheath. The sternal portion of the muscle usually appears to be more contracted than the clavicular, but it will almost always be found necessary to divide both. The division should be carried out a short distance above the clavicle, and not close to that bone, and it should be done by the open method, for by this procedure alone is it possible to divide the muscle and fascia completely without risk of injury to the veins.

FIG. 491.—WRY-NECK DUE TO CONGENITAL CONTRACTION OF THE RIGHT STERNO-MASTOID MUSCLE.

The curved incision will expose both heads of the muscle—sternal and clavicular—which need division.

It will be remembered that three important veins are in close relation to the sheath of the muscle—namely, the internal jugular to its deep surface, the external jugular to its posterior border at this level, and the anterior jugular to its inner edge and deep surface. The subclavian and the beginning of the innominate veins are also very near its extremity. As several disasters have occurred from puncture of one or other of these veins in subcutaneous tenotomy, and as aseptic precautions do away with any reason for preferring this method, we strongly advise the open incision.

Operation.—A general anæsthetic is given, the head and shoulders are well raised, the surgeon stands on the same side as that of the contracted muscle. By means of two incisions, one over the anterior edge of the muscle, the other parallel to and a little above the clavicle, the latter running across both heads of the muscle, a small triangular flap of skin and superficial fascia is turned outwards. The assistant, who steadies the patient's head, makes the contracted muscle as tense as possible whilst the surgeon steadily divides first the sternal and then the clavicular portions and the fascial band. The division is done gradually from before backwards with a blunt-pointed tenotome or fine scalpel, and the large veins are looked for and carefully avoided. The posterior part of the sheath will usually be found to require division or stretching. By this deliberate and open division the risk of recurrence of the deformity is to a great extent avoided, and the

necessity for wearing irksome apparatus largely dispensed with. The small flap of skin is fixed in place with a few fine silkworm-gut sutures, and dressed with gauze and collodion or some other light and dry dressing.

During the following week the patient should remain in bed with the head maintained in proper position between sand-bags. He should be kept under observation for some months after the operation, and encouraged to exercise the cervical muscles so as to prevent tendency to recurrence. In a few instances the apparatus employed in cases of wry-neck needs to be worn for some months.

Mr. Tubby (*Brit. Med. Journ.*, June 16th, 1906), instead of the incision given above, advocates an oblique one made at the anterior border of the contracted sterno-mastoid muscle. He also insists on the necessity for applying a plaster-of-Paris splint to the neck to keep it in the over-corrected position. This splint can be readily fashioned out of house-flannel, which is soaked in the plaster, the skin being protected by linen bandages. It is worn for two or three weeks; subsequently a leather or poroplastic collar for the neck is worn for some months. As we have seen perfect results without the use of this irksome apparatus, it is certain that it may be dispensed with in most cases.

For the treatment of "spasmodic torticollis" by resection of the posterior spinal nerves in the neck, *see* page 98.

CHAPTER II

TENDON-SUTURE, TENDON-GRAFTING, ETC.

In this chapter are considered the operations undertaken for the primary and secondary suture of cut tendons, methods of tendon-grafting and tendon-transplantation, and the indications for and means of lengthening and shortening tendons.

Tendon-suture.—In all cases of tendons divided in an open wound, attempts must be made to secure an accurate apposition of the ends by means of a primary operation. In most cases, where the condition has not been diagnosed at the time of injury, or where the conditions are such that primary suture cannot be accomplished, a secondary operation will be required owing to the amount of disability caused by the loss of function of the part to which the tendon is united. In a large number of cases in which a subcutaneous rupture of the tendon has occurred, suturing will be the best or only means of securing good union between the divided ends.

Primary Suture of Cut Tendons.—Injuries involving division of tendons usually occur in the forearm in the neighbourhood of the wrist. As is to be expected, they are more common in those whose duties include heavy and dirty work. The wounds are therefore often lacerated and septic. Tendons are composed of fibrous avascular tissue, and depend almost wholly upon the sheath for their nutrition. For this reason it is essential that the wound be made aseptic and kept dry, for, if these conditions be not fulfilled, failure of union is very likely to occur. Special precautions, which will be described in detail, must be undertaken to attain these results.

The patient having been anæsthetised, the wound is plugged with aseptic gauze, and the structures around shaved and thoroughly cleansed. Any microscopic foreign bodies and lacerated tissues which are visibly dead are now removed, the wound is cleansed with soap and water, turpentine and an alcoholic solution

of biniodide of mercury, the tissues being only gently washed with the reagents, with the aid of sterilised gauze and swabs. It is now thoroughly washed out with saline solution to remove the reagents, which might later cause irritation. An assistant then applies a tourniquet well above the site of the injury.

The tendons are now isolated and identified. In the majority of cases the wound is transverse, and to aid in the identification of the tendons a longitudinal incision will probably be found necessary. To keep the identified tendons separate it will be found most useful to pass a long suture through any two corresponding ends. The sutures are then loosely knotted until all the tendons are identified, and the surgeon is prepared to approximate their ends.

About $\frac{1}{8}$ inch is now cut off the ends of each tendon, so that no dead tissue is left behind. All vessels having been ligatured, the ends are finally sutured. For this purpose fine catgut is probably best, but, if no suppuration occurs, good results follow the use of Pagenstecher thread, which is more reliable and readily knotted. As the fibres of the tendon are arranged parallel to its long axis, the sutures have a tendency to cut out. Many methods have been adopted to overcome this tendency. The method known as Le Dentu's suture will in the majority of cases be found quite satisfactory. Here a tension suture is passed through both ends, traversing the whole thickness of the tendon about $\frac{1}{2}$ inch from its extremity. Good apposition is then obtained by the use of approximation sutures, which pass only partially through the substance of the tendon and close to the extremity. The tourniquet is then removed and any bleeding points which may have previously escaped notice firmly secured. The individual tendons may now be wrapped in Cargile membrane to prevent adhesions. A small tube or gauze drain is inserted, and the skin united with silkworm-gut sutures. The wound is dressed with gauze, and put up on a curved splint so as fully to relax the divided tendons. The drain may be removed at the end of forty-eight hours.

Secondary Suture of Cut Tendons.—In this case, where some interval has elasped between the time of the division and that at which treatment is sought, an operation is undertaken on lines similar to the above; but whilst the difficulties in maintaining

asepsis will be less, there will be an increased difficulty in identifying the tendons, in freeing them from adhesions, and in approximating their ends. Thus three conditions will have to be considered :—

1. Where the ends, having been freed and identified, can be approximated without undue tension.

2. Where both ends can be freed, but cannot be easily approximated.

3. Where only one end can be found.

In the first group the operation will be continued on the lines laid down in the preceding section, the ends being carefully sutured together and then wrapped in Cargile membrane. The after-treatment should be so conducted as to prevent adhesions, but should not be sufficiently vigorous to separate the newly-joined ends.

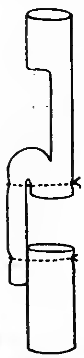

FIG. 492.—TONKA'S METHOD OF BRIDGING A GAP WITH A FLAP.

In the second group some means of tendon-lengthening or grafting must be undertaken as described below.

In the third group a means of tendon-anastomosis may be utilised.

Tendon-lengthening.—It may be necessary to lengthen tendons, either because the ends have become separated by a considerable distance as in many cases of secondary suture, and in cases where it has been necessary to remove a portion of the tendon for pathological conditions of or involving it, or because the muscle and tendon have become contracted so that full extension of the part to which the tendon is attached is no longer possible. Many ingenious methods of so lengthening tendons have been utilised, but only a few can be described here.

1. *Where the ends are separated by a considerable distance.*—The two ends having been bared, a double suture is passed through the proximal portion near its extremity. A flap is turned down from this piece, the flap being saved from complete separation by the suture already passed. This flap is utilised to bridge across intervening space and is sutured to the distal end (Tonka). (Fig. 492.)

Where the tendon is wide and flat, zig-zag incisions may be made into it laterally. On pulling on the end, these incisions separate out and the tendon is lengthened.

In certain cases where the division of the tendon is close to the insertion, the gap may be bridged over by separating with a saw or chisel the bony point of insertion and fixing it to the main portion of the bone at a higher level. This has been done in the case of division of the tendo Achillis (Poncet).

When the tendons are so small that a flap would be likely to slough, and the division is too high up to allow of osteotomy, the gap may be bridged across by strands of suture which probably act as a scaffolding around which firm fibrous tissue is laid down. Grafts taken from the same or other tendons have been utilised in a similar manner.

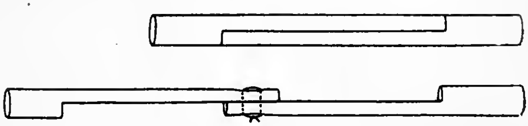

FIG. 493.—ANDERSON'S METHOD OF TENDON-LENGTHENING.

2. *Where the tendon is in continuity but is contracted.*—Here the method introduced by Anderson is the most serviceable, and gives the firmest union. The tendon having been laid bare, a **Z**-shaped incision is made through it; the central bar of the **Z** runs vertically down, and is made $\frac{1}{2}$ inch longer than the amount by which it is desired to lengthen the tendon. The two pieces of tendon are now slid down, and the ends sutured with catgut (Fig. 493).

Tendon-anastomosis.—This is chiefly required in cases of cut tendon, where, a secondary operation having been performed, the distal end of the tendon can alone be found, the proximal end being so retracted that it is difficult or even impossible to isolate it.

The proximal end, having been found, is freshened, and is then cut obliquely. A neighbouring tendon which has been selected for anastomosis is now isolated for a short distance, and a small vertical incision is made through the middle of its length. The small buttonhole thus made is opened up and the end of the cut tendon inserted; sutures of thin catgut are now passed to hold the two portions in apposition. Instead of this a small slip may be cut from the healthy tendon, turned

outwards, and joined end to end with the cut tendon, which in this case is cut square and not trimmed to a point as in the last case (Schwartz). (Fig. 494.)

Tendon-transplantation.—This operation has chiefly been undertaken in cases of paralysis of individual muscles, such as occurs after anterior poliomyelitis, and this means of treatment has now become a large branch of orthopædic surgery. The subject is too large a one to be entered into fully here, and a brief description of one or two of the principal methods adopted can alone be given.*

In most cases the tendon to be transplanted should belong if possible to the same group as the paralysed one, and should act parallel to it. In some cases, however, it is better to transplant an opponent of the paralysed muscle, as by this means the deformity is more likely to be overcome.

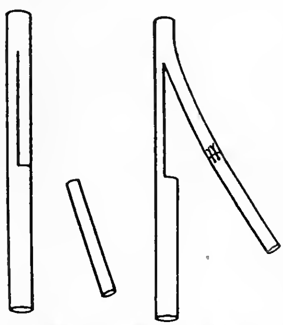

FIG. 494.—SCHWARTZ'S METHOD OF TENDON-ANASTOMOSIS.

If the tendon to be transplanted is in close proximity to the paralysed one, a single incision is made; if separated by any distance, two smaller ones are preferable, one over each tendon, and these are laid bare. There are many methods of proceeding from this stage, but the three following are those most commonly adopted.

1. The healthy tendon is completely divided, and the proximal end is united to the paralysed tendon, preferably by suturing it into a buttonhole prepared in the latter.

2. A slip is cut from the healthy tendon and implanted into the side of the paralysed one.

3. A slip is cut from the healthy tendon, the paralysed one is divided, and its distal end sutured to the end of the slip, as in Schwartz's method of tendon-anastomosis.

In uniting the two ends, silk sutures may be used, and the healthy tendon should be stretched, but this must not be overdone;

* For a full account of this subject the reader is referred to Tubby and Jones's "Surgery of Paralysis." Macmillan, 1903.

the stretching must be kept well within the bounds of the elasticity of the muscle. The incision is sutured, and the limb now placed in the fully corrected position so as to relieve tension, and kept immobilised in this position for from four to six weeks, after which massage, gentle passive movements and faradism should be employed daily.

Tendon-shortening may be undertaken in some cases resulting from old anterior poliomyelitis, where deformity is present, but it is essential, before undertaking the operation, that active tissue be found in the affected muscle—a point which may be best determined by a careful investigation of the electrical reactions. If no muscular tissue be present, such an operation is of necessity bound to fail, and, although the deformity may at the time be corrected, the tendon will again stretch as soon as the limb is used. For such cases some form of tendon-anastomosis as described above is indicated.

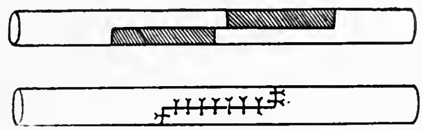

FIG. 495.—ANDERSON'S METHOD AS APPLIED TO TENDON-SHORTENING.
The shaded area is the portion removed.

The method which gives the firmest union is an adaptation of Anderson's method of tendon-lengthening. The tendon having been laid bare, a **Z**-shaped incision is made through it, the central end of the incision running vertically down the middle of the tendon. The pieces being separated, as much is removed from each end as it is desired to shorten the tendon by. The two portions are now sutured together (Fig. 495).

Removal of a portion of the whole thickness of the tendon, followed by simple end-to-end suture, is but rarely successful. Union is enacted by simple fibrous tissue, which is very liable to stretch and allow the tendon again to lengthen.

INDEX TO VOL. II

U

V

W

Z

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